POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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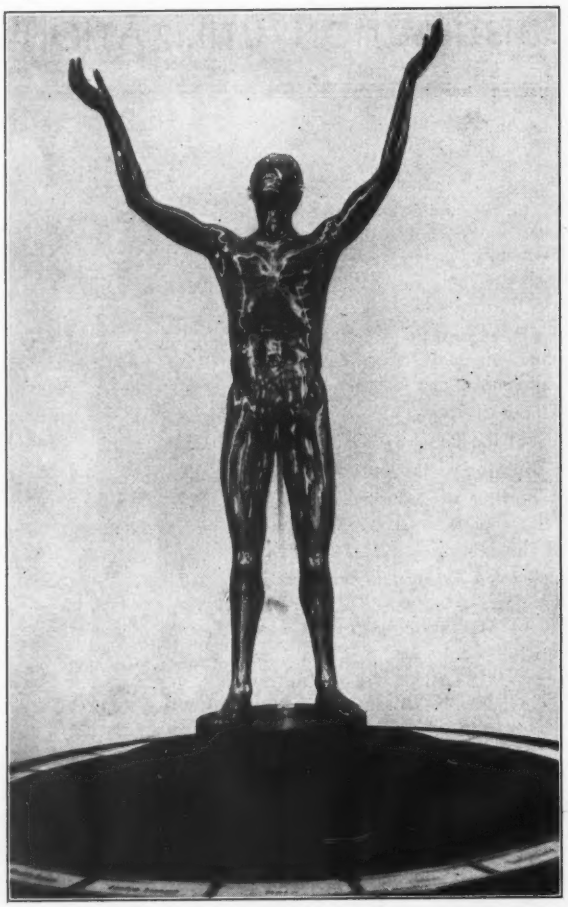
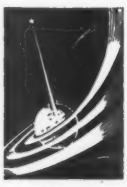
A CENTURY OF PROGRESS



The Transparent Man



AMONG the various forms of trickery practiced at circuses and county fairs there used to be one in which the victims were told that for 25 cents they would be shown something they had never seen before and that they would never see again. Thereupon, after collecting the required "two bits" the sharper would break the shell of a walnut, hold the kernel up to view and calmly proceed to eat it.

Excluding the element of deception, the Century of Progress exposition at Chicago reminds one of this story. It will be something nobody has ever seen before and in all probability nobody will ever see anything quite like it again. From its opening on May 27 by a light beam from Arcturus, to its termination five months later, it promises to be different from all other world fairs in every respect. Not only in its unique architecture, but also in the character of its exhibits, this "fair" will show the world something new. Nobody who has not seen the technical exhibits under construction can have any conception of the effort that has been expended in making them possible.

In this issue, in describing some of the exhibits, we have just scratched the surface, so to speak. We have outlined the plan and character of the "Science" exhibits and have endeavored to present a general picture of the principal industrial exhibits in which power engineers will be interested, but to really describe them in detail would take a year's issues. Take the "glass man" for instance. We have said nothing about him because, technically, he does not come within our field—the field of power engineering—yet, logically, he is of great interest to engineers of all branches. His construction involves as truly a remarkable feat of "engineering" as anything made of steel or iron. Brought over from Germany, this transparent model of the human body, heroic in size, shows with remarkable clarity, the skeletal, nervous, vascular, respiratory, digestive and muscular systems. By means of this model, the observer visualizes human anatomy as though his eyes possessed the penetrating power of X-rays. It is a striking feature of the medical exhibit.

So, too, the "communications" exhibit is of distinct interest to power engineers since it involves the application of electrical power in its more delicate and complex forms. We should like to have had space in this issue to describe it in detail since it is one of the most interesting at the entire exposition, but since it does not come directly in our field we can only mention it here. Not only will the operation of modern telephone and telegraph systems be shown to the last detail, but such things as scrambled speech, delayed speech and a multiplexing will be demonstrated.

As pointed out recently on this page, A Century of Progress is dedicated to the spirit of achievement through science. So in this issue, which is dedicated to the Century of Progress Exposition, we have endeavored to show what present day science is and how it finds expression in the exhibits at the exposition, particularly as it interests the technically minded man. It has been our aim to indicate that this is no ordinary "show"—not just a conglomeration of unrelated, spectacular exhibits. True, many of the exhibits are spectacular, but the spectacular element is in most instances of secondary importance; the primary consideration is education. Though the scientific exhibits are fundamental in character, they demonstrate the utility of science in industry in a way so that the visitor may acquire a permanent interest in the link connecting basic science with progress. In this way it is expected that life, definiteness and intelligibility will be given to principles which are commonly supposed to be too abstract for general comprehension.

WITH THE EDITORS

Power, Pure Science and A Century of Progress

BACK OF ALL the tremendous industrial development which has taken place during the past century was a foundation of scientific facts upon which men have worked to develop materials, processes and machinery that have been eagerly sought by people throughout the entire world in their growing enlightenment and cultural development. Lifting the human race out of the class of beasts of burden and putting it in control of natural forces that are capable of supplying the necessities of life has been the task of engineers whose accomplishments during the past century are far beyond that of any similar period recorded in history.

This fact was recognized by the officials in charge of A Century of Progress Exposition and has been made one of the principal themes of the undertaking—the development of scientific discoveries into things of use to mankind. Couple this with the many other things of human interest which have taken place during the hundred years that Chicago has been a city and we believe no visitor to this exposition will go away without many lasting impressions and information distinctly useful in his work no matter what that may be.

To the scientist, the engineer and the industrialist, particularly, are the exhibits of special interest. The pure science exhibits are wonderfully instructive, carrying the observant visitor almost unknowingly to an understanding of many principles in mathematics, chemistry, physics, electricity, biology, geology. Applying these sciences to industry are numerous process exhibits acquainting the visitor with factory methods in many of the principal industries. Throughout the entire exposition, the application of power in one or more of its forms is evidence of how universally we are dependent on power generation from fuels and waterfalls to maintain our present-day civilization. This application has been developed almost entirely during the past century and can be credited with many of the advantages claimed for our civilization over those of past ages.

It is our interest in the generation and application of power that has impelled the editors of Power Plant Engineering to the presentation of this number of the magazine devoted principally to an exposition of scientific and industrial developments of the past century as exemplified by the things to be seen at A Century of Progress. Scientific truths have always been known far in advance of industrial application of the principles involved, entirely too far. Many scientific toys have lain dormant for generations before some genius found an application that performed a needed function. Many of our needs in industry are still unsolved, yet probably so simple is the solution that to the man familiar with the problem a mere suggestion of some fundamental principle may be all that is needed for a complete solution. The Hall of Science is filled with numerous models demonstrating mathematical, physical and chemical principles as they are known today—a veritable animated book of knowledge. Many of the mysterious doings of equipment in power plants will lose their power over the man who reasons back to first principles which will be found demonstrated here.

Criticism has been made of the engineering profession, and not without justification, that the time gap between the discoveries of scientists and industrial application is greater than conditions justify, that many economies are possible by application of recent scientific discoveries, and that engineers neglect to keep themselves thoroughly posted on research work in pure science. The articles in this issue have been prepared to give the reader an idea of how the principles of mathematics, physics, chemistry and electricity and the application of these branches of pure science to industry, particularly the art of power generation and use, are demonstrated by the various exhibits at A Century of Progress.

Past expositions of comparable importance have initiated developments such as the telephone, alternating current machinery, steam turbine, decorative and sign lighting, and at this time a special effort is being made to interest the public in the results which have been obtained in research laboratories. As applications of many of these laboratory products are still in their infancy, it is only reasonable to expect that many new applications will result from this exposition which will be visited by scientists and engineers from all nations.

Religion, philosophy, architecture, art, literature, music, military conquest, exploration have all had their day on the stage of human thought and each has left with the human race strains of mental development that have resulted in the civilization we know today.

Up to a century ago, science in all its branches was substantially a philosophy, a knowledge of the causes of phenomena. Its application to living conditions was only meagerly resorted to and the foundations for professional engineering, as we know it today, were just beginning to be laid. The machine age came into being and is still flourishing, thanks to the application of the tools of science.

As we look back we find only the primitive types of machinery recorded in the history for the times of one hundred years ago. Water power was used inefficiently at the site where it was developed. Steam was just begining to be used as a source of power for industrial purposes. Animals and humans furnished practically all the power used in all walks of life. From this condition we have progressed through the inefficient use of water falls and fuels to highly economical methods of generating power and distributing it for use not only in industrial centers but in nearly every village and hamlet in the country.

A Century of Progress Exposition has as its basic theme one which "dramatizes the achievements of mankind, made possible through the application of science to industry" and in subsequent pages of this issue some of the pure sciences are discussed in order that readers may more closely associate their problems with the fundamental facts recognized in pure sciences.

POWER PLANT ENGINEERING June 1933

An Engineer Sees the World's

A general description of the things of principal technical interest at the Century of Progress. The "engineer" will find much to hold his interest first in the Hall of Science proper where the basic science exhibits are shown and later in the "electrical group" and in the many industrial exhibits to be found throughout the Fair.

PICTURE yourself, if you can, a Rip van Winkle going to sleep in a Pullman berth tonight and waking up tomorrow morning, as many will do this summer, on the lake front in Chicago. Twenty years have not passed since you went to sleep but don't be surprised if you find some things as strange, unfamiliar and unbelievable as did Old Rip after his sojourn in the hills. In one night you will have changed your surroundings to such an extent that you can easily imagine yourself come back to a civilization twenty years from now after an incommunicable absence. Meccano toy buildings developed into giants; architecture revolutionized; dwellings of strange materials; roofs supported by cables; manufactured weather; dinosaurs come back to life; glass houses; strange lighting; man-made reproduction of the heavens; inner workings of the atom; photos taken in the dark; battles fought in a drop of water; music over a light beam; corn popped without heat; doors open automatically as you approach; metals supporting themselves in mid-air; inverted speech; one way window glass. Confusion confounded? Well, no. Just science and industry coördinated.

Like the theme of the project, A Century of Progress Exposition which opens on May 27 in Chicago by an electrical impulse initiated by a beam of light from the star Arcturus, is laid out in scientific arrangement and a trip through the grounds and buildings if taken in proper order will reveal the secrets to the mysteries scientists have discovered.

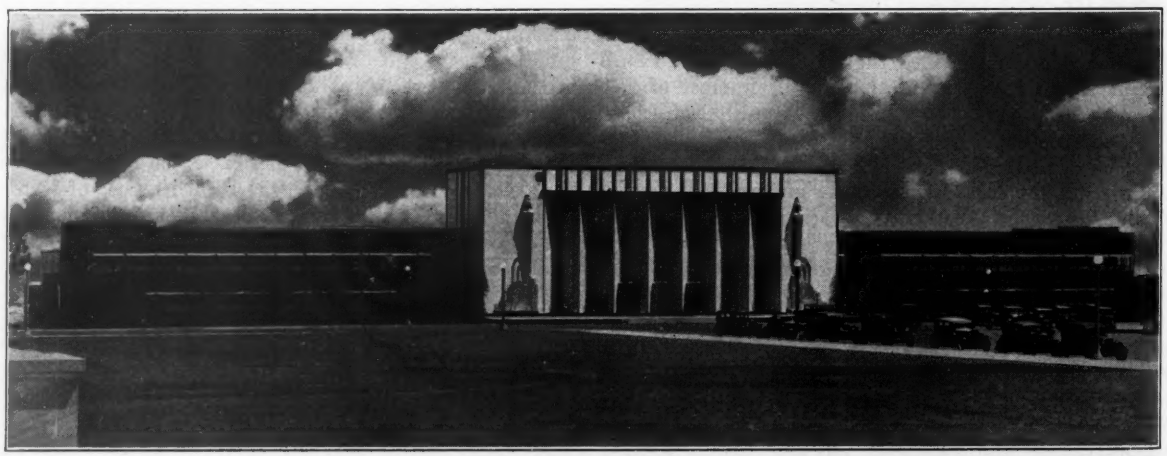
This is an educational undertaking in practically all branches of science, so the Hall of Science may be considered the hub of the exposition. In it are displayed every manner of device designed to aid the visitor to an understanding of the laws governing basic sciences, extremely simple, wonderfully clever, intrigueingly fascinating. Mathematics, physics, chemistry, geology, biology with many of their branches are treated here in a way that will clarify many previously hazy conceptions.

Education Made a Feature

From this as a beginning the visitor will undoubtedly want to dip into advances of his own special line of work. This opportunity is given him in the various buildings devoted to these special subjects. To the power engineer the electrical group, three buildings joined together by connecting sections, will make an irresistible appeal. The approach to this group is by means of a bridge over the lagoon making a direct connection between the Hall of Science and the Electrical Group symbolical of the union of the two.

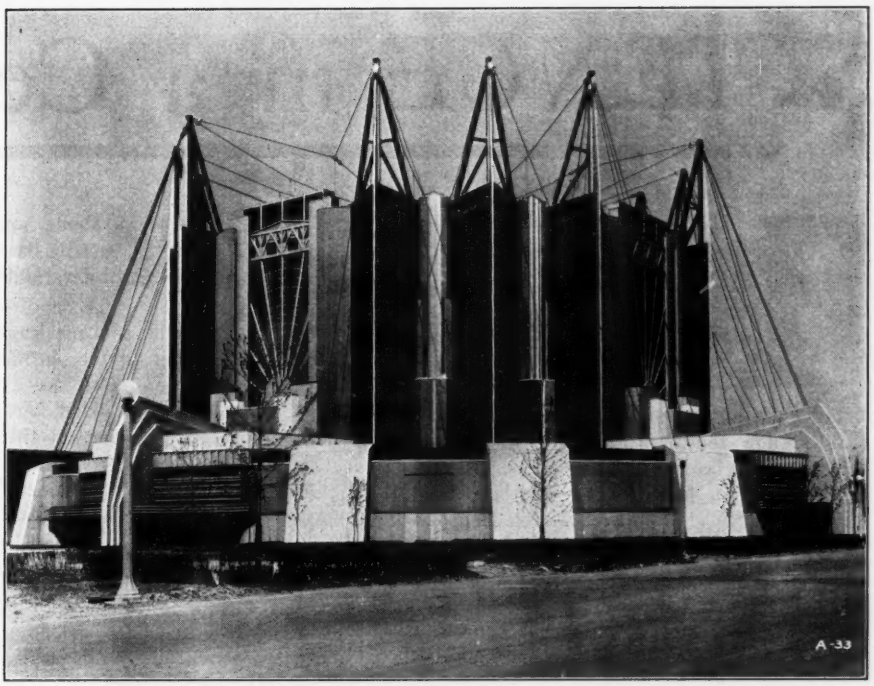
At the north end of the group is Radio Hall which houses the radio exhibits. This is probably, from a historical viewpoint, the most complete scientific exhibit on the grounds for it is of comparatively recent development and all important laboratory developments have been carefully preserved for display on occasions of this sort. Not only the early crude radio apparatus but some of the most recent equipment used in experiments in television is to be seen here.

Communication Hall is directly south of Radio Hall



The Administration Building—Headquarters of "A Century of Progress."

's Fair



Larger than the dome of St. Peters or the capitol at Washington, this "sky hung" dome of the Travel & Transport Building strikes a new note in architecture. The roof is formed of metal plates suspended by steel cables. It is the first application to architecture of the principle of the suspension bridge. The dome is 200 ft. across.

with a connecting section between. Here are to be found the exhibits of wire communication, including the telegraph, telephone and their contribution to modern civilization.

Still farther to the south is the semi-circular Electrical Building where an insight into the generation, distribution and utilization of electric energy will be given by the exhibits of public utility companies and electrical manufacturers. Electrical equipment for the home, office and farm; devices to assist the dental and medical professions; devices used in manufacturing processes; most recent developments in electrical devices for industry and laboratory use; demonstration in the use of power and light for comfort, convenience and beauty; all these will be found in the Electrical Building in extremely attractive displays.

Memorial to Edison

Adjoining the Electrical Group on the lagoon's edge is the Edison Memorial which in its design is an attempt to reproduce the spirit which Thomas A. Edison represented to the world. The Memorial will house displays setting forth fundamental discoveries of the great inventor and many flowers and plants from his garden in Orange, N. J., have been transplanted in an attractive garden outside the Memorial.

To the power engineer who has gone through these buildings his next interest will probably be found in the application of power to the various industries with which he is most intimately associated. For exhibits in these industries, reference should be made to a map of the grounds.

While on the island, however, men interested in science will find many valuable ideas in the exhibit of the Bureau of Standards in the Federal and States Buildings north of the Electrical Group and farther north in the Agricultural Group the application of power may be studied to advantage.

Then, to divert one's mind from the intensely practical, a visit to Adler Planetarium where the entire universe is pictured in motion will be in order as its location is at the northernmost point of the island.

Entertainment in Abundance

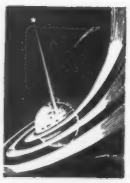
From this point on specialization and amusement will occupy the time of the visitor and there is no lack of either. Aside from the pleasure of a trip on the Sky Ride, for instance, an engineer will find this structure and its working mechanism worthy of more than passing attention as it has already been put to practical use in Great Britain as a substitute for bridges over wide spans without interfering with shipping.

In the General Exhibits Group will be portrayed the stories of the graphic art, furniture, office equipment, jewelry, cosmetics and textile industries. To the south from this point are the buildings erected to house the exhibits of individual companies and coöperating industries, historical exhibits, Midway of the exposition, model homes and industrial arts group of buildings. At the extreme south end of the grounds a stage is erected for the enacture of the Pageant of Transportation near by the Travel and Transport Building which every engineer visiting the exposition should make special arrangements to see.

At every turn a surprise is in store for the observant visitor and electricity, the product of power plants, plays no small part in the features of this exposition. Spectacular in the extreme are the architectural features of buildings erected here. Modernistic art of sharp angles and contrasting colors has been worked into designs that grow in the appreciation of the observer and the lighting effects employ every device known to science to create a symphony of brilliant light and color.

POWER PLANT ENGINEERING June 1933

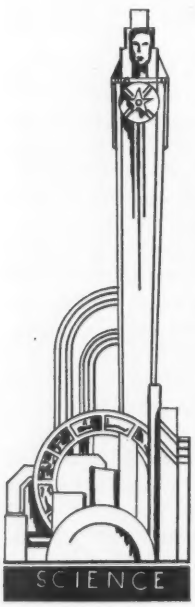
SCIENCE in a Century of



TAKE THIS FISH," said Agassiz to a student who entered his laboratory to study zoology, "look at it; we call it a Haemulon; by and by I will ask you what you have seen." In ten minutes the student thought he had seen all that could be seen in the creature without a magnifying glass but when he commenced to draw it he discovered new features and upon the return of Agassiz several hours later he rehearsed what he had observed. "You have not looked at it very carefully," said the naturalist, "why, you haven't even seen one of the most conspicuous features of the animal which is as plainly before your eyes as the fish itself; look again!" And so for three days the student was kept examining the fish before Agassiz was satisfied that he had discovered for himself the essential parts of its structure. On the fourth day a second fish of the same group was placed beside the first and the student was bidden to point out the differences between the two. Another, after another followed until the entire family had been examined and classified.

Thus the scientist digs out facts, step by step, holding fast to those that are good and arranging them in their proper place until finally some general law is discovered. There is nothing mysterious about the process, it is nothing but the correlation of keen observation with common sense. Indeed, as Huxley said, "science is nothing more than trained and organized common sense."

It is upon this basis, upon the steady and orderly accumulation and arrangement of facts that the whole of our present scientific world is founded. It rests upon a solid foundation of truth.



And yet, despite this comparatively simple fundamental foundation upon which all scientific developments rest, most people not scientifically minded are inclined to regard science as something mysterious, something bordering on the supernatural and brought about by conjurers and necromancers. Even the simplest achievements of science they believe forever beyond their understanding and so never make an attempt at understanding them. It is rather pathetic that this condition should exist in a world which is so dependent upon the work of scientists. And it is curious, indeed, that down through the centuries people who have never hesitated to argue about how many angels could stand on the point of a needle have consistently closed their eyes to the simple understandable properties of a triangle.

Whether this condition is due to a fundamental twist in the average human mind or whether it is due to the fact that scientific matters have never properly been presented to the average public, is not the question to be discussed here; it may be due to a little of both. The important thing here is that at the Century of Progress Exposition, for perhaps the first time in history, an intensive effort has been made to acquaint the public with the fundamentals of scientific development.

As has been pointed out elsewhere in this issue, the keynote of the Century of Progress Exposition is progress through science and its applications. This theme is expressed generally throughout the entire exposition, but it centers in the Hall of Science. It is in this building that the spirit of scientific achievement finds concrete expression; it is here that the basic principles of physics, chemistry, biology and mathematics are shown.

The exact methods in which these branches of science are presented to the public are extremely interesting but before we discuss them it is desirable to consider broadly the state of science and the interrelationship of its various branches today. For the state of science today is quite a different thing from what it was a hundred years ago, 50 yr. ago or even 20 yr. ago. It has grown; it has changed; it has given birth to concepts and new understanding and it has affected every phase of human activity. It has remade the world.

Insofar as possible, the various exhibits in the respective branches of science in the Hall of Science are grouped separately, that is, there is a division devoted to physics, one to mathematics, another to chemistry and so forth. This is desirable and convenient since it places exhibits of a similar character together, but in a larger sense, the Hall of Science must be regarded as a single unit, not as an agglomeration of separate branches of knowledge.

For all the sciences, or perhaps we should put it, all the various branches of science, are related. There was a time when physics was quite separate and distinct from chemistry, and so also were the various divisions of physics; mechanics, heat, sound, light, electricity, and magnetism quite separate and distinct from each other. These terms were regarded as referring to distinct and unrelated aspects of material phenomena. But today this is no longer true. A historical survey of the science of physics reveals as perhaps its most significant fact, the evolution of this field of knowledge with respect to an ever increasing correlation of material not obviously connected with it.

Chemistry, for example, is constantly becoming more and more related to physics; the physics of the atom and the electron. Chemical combination, the action and reaction of various substances today are explained not

Progress

upon arbitrary assumption or empirical laws but upon the exact knowledge of the electrical properties and reactions of atoms and electrons. The chemical equations of today are filled with electrical symbols!

And so, in all other branches and sub-branches of science, each one has overlapped the other until today there are practically no lines of demarcation remaining. If, today, there is still one line which sharply divides one branch of science from another, perhaps it is the one which distinguishes the organic from the inorganic. But it is questionable whether even this line will stand very much longer. At present it is still quite unassailable, but it is not entirely improbable that this last line of demarcation will also be shown to be indefinite and that when reduced to this ultimate simplicity, there may be no marked distinction between living and non-living things.

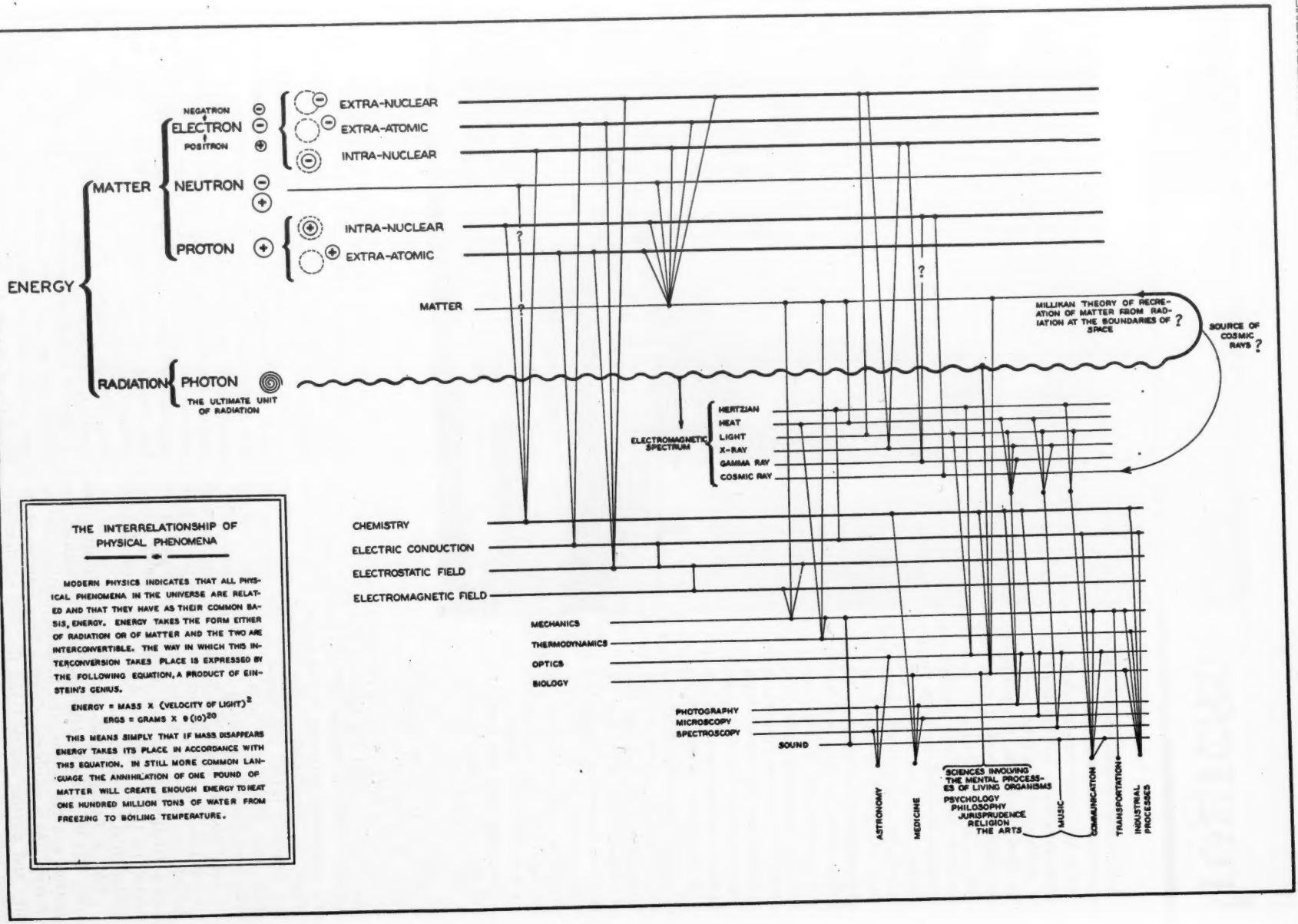
The thing that has brought this unification of science about is the overwhelming urge on the part of a certain few of mankind to know the ultimate nature of things — to reduce the world and the universe to its utmost simplicity. At a time when the world was made up of a large number of radically different things—all the various compounds and substances, naturally it was logical to divide these things up into classes. The chemist and perhaps the alchemist before him urged by the hope of creating gold from baser metals, found that complex substances could be resolved into simpler ones. This list has since grown to 92. When these elements were arranged in the order of increasing weights a curious rhythm was noted in the list. This was puzzling for such a relationship between things presumably fundamental in their character was a challenge of their fundamental character.

And so finally the electron theory of matter was born. The 92 elements crumbled into two entities, the electron and the proton, the ultimate particles of the universe. As a result the dividing lines between chemistry and physics vanished and the field of electricity spread into chemistry.

Thus far energy has been a thing apart. The law of the conservation of energy had been enunciated, light, heat and electric waves were known to be forms of energy, but beyond that little was known.

About 1900, however, Max Planck presented the celebrated "quantum" theory which showed that energy was corpuscular in nature—that it consisted of lumps or particles. From this finally arose the concept of energy-matter, the idea that matter and energy are interconvertible and continued research has to a certain extent substantiated this. According to present theories mass and energy are interconvertible; if mass disappears energy takes its place in accordance with an equation developed by Einstein. For every gram of matter that vanishes, 2.13×10^{13} calories of energy are liberated.

Thus it is that there seems to be a common basis for everything and all phenomena in the universe—this basis being energy. Energy, it seems, can take either the form of matter or of radiation. Matter, so far as known, is composed of electrons, protons and neutrons in



THE INTERRELATIONSHIP OF PHYSICAL PHENOMENA

MODERN PHYSICS INDICATES THAT ALL PHYSICAL PHENOMENA IN THE UNIVERSE ARE RELATED AND THAT THEY HAVE AS THEIR COMMON BASIS, ENERGY. ENERGY TAKES THE FORM EITHER OF RADIATION OR OF MATTER AND THE TWO ARE INTERCONVERTIBLE. THE WAY IN WHICH THIS INTERCONVERSION TAKES PLACE IS EXPRESSED BY THE FOLLOWING EQUATION, A PRODUCT OF EINSTEIN'S GENIUS.

$$\text{ENERGY} = \text{MASS} \times (\text{VELOCITY OF LIGHT})^2$$

$$\text{ERGS} = \text{GRAMS} \times 9(10)^{20}$$

THIS MEANS SIMPLY THAT IF MASS DISAPPEARS ENERGY TAKES ITS PLACE IN ACCORDANCE WITH THIS EQUATION. IN STILL MORE COMMON LANGUAGE THE ANNIHILATION OF ONE POUND OF MATTER WILL CREATE ENOUGH ENERGY TO HEAT ONE HUNDRED MILLION TONS OF WATER FROM FREEZING TO BOILING TEMPERATURE.

various combinations. Electrons and protons again may be classified according to their position in the atom or outside of the atom, that is either as intranuclear, (inside of, or composing the nucleus), extranuclear (in orbits surrounding the nucleus), or as extra-atomic (outside the atom entirely). Quite recently, in researches on cosmic rays, Anderson in California and Occhialini in England, another entity has been observed which seems to be neither an electron or a proton—a particle having a positive charge but with the mass of the electron. The name of positron has been suggested for this unit and since that leaves the negative electron in a rather illogical position, the name negatron has been offered to designate the counterpart of the positron.

Given these fundamental entities, the electron, the proton and the neutron, it is possible to correlate all phenomena in the universe as has been attempted in the accompanying chart. This chart must not be accepted too seriously for our knowledge is still incomplete and probably will remain incomplete for a long time to come, but its general plan may be regarded as true. We are, for instance, quite certain that the laws of chemical combinations upon which the whole science of chemistry is founded rest upon the effects of intranuclear protons and electrons. It is true the extranuclear electrons and extra-atomic electrons and protons also are involved but these are involved only because of certain unbalances between the intranuclear protons and electrons.

Electric conduction involves the motions of extra-atomic electrons and protons under the influence of the electrostatic field, which in turn is related to the electromagnetic field, since a moving electrostatic field produces a magnetic field.

The electrostatic field itself is the consequence of the unbalances between extra-atomic protons and electrons and extranuclear electrons. These fields, electrostatic and electromagnetic, combined give rise to radiation of all kinds, radio, heat, light, x-ray, gamma ray and cosmic ray.

These various types, which after all signify nothing more than differences in frequency of the radiation in their effect on matter and our observation of these effects, give us the fields of mechanics, thermodynamics, optics, and biology. These in turn lead to such sciences as astronomy, geology, microscopy, photography, etc.

To those in some way familiar with modern scientific theories, these relations need no explanation, but to those who have not kept abreast of developments in atomic research, they may be mystifying. What relation one may ask has mechanics, which deals with matter in motion, to do with electric and magnetic fields as indicated in the chart? The answer is that it has everything to do with it, that electric and magnetic fields govern the motion of material matter just as much as they do of electrons and protons. If this seems mystifying, ask yourself what is the difference, say, between a baseball passing through space and one that is lying at rest on a table. None, you may say, for the sake of argument. But there is, otherwise why would the one continue in motion. "Oh," you say, "that is because you have endowed one with kinetic energy."

But this tells us nothing. What is kinetic energy? Where is it in the ball? As long as we regard the ball merely as a solid mass we can find no suitable explanation of its motion through space, but as soon as we look at the ball, not as a single solid mass but as a collection of atoms and electrons, separated from each other by vast distances relative to their magnitude, we can form an idea as to what happens. When the ball is struck by the bat, one side of it is flattened by compression. Thus the fields of the atoms are flattened and compressed. This pressure is voltage, which acting on the ball (that is on the atoms of the ball) ejects the ball just as voltage ejects an electron in a vacuum tube. The distorted fields tend to adjust themselves thus driving the atoms forward. This displacement results in the production of additional magnetic field. Since this field takes time to build up sudden motion is resisted and it is this resistance to motion that we call inertia. Finally, as the ball leaves the bat, its atoms are all in steady motion, a slow moving direct current of electricity moving across space.

In this way mechanics can be explained electrically, just as chemistry must be explained electrically. The chemist is beginning to recognize this fact much more than the mechanical engineer, but some day perhaps an electrodynamic theory of mechanics will be written that will serve in place of our classical theories.

In this way also all other everyday phenomena can be explained in terms of the actions of electrons and protons, whether it be the motion of a baseball, the flashing of a light, the explosion of a charge of powder, it doesn't matter, fundamentally all are based on the same things.

If the Hall of Science at the Century of Progress is viewed with this thought in mind, it will prove immensely more interesting than if the exhibits are regarded as more or less separate classes of phenomena, each representative of a certain field of human endeavor.

In the accompanying chart, which it must be understood is not presented as being complete to the last detail, mathematics receives no recognition. That of course is due to its abstract character. Mathematics deals with all of the items on the chart and for this reason it has correctly been termed the Queen of the Sciences. And perhaps in the ultimate analysis, mathematics is more closely related to all the sciences than we even suspect. Under the quantum theory and wave mechanics, the newer developments of physics, it is possible to think of the fundamental entities of the universe, not as waves or particles, but as mathematical equations.

This may seem absurd but we have no alternative. We find we can no longer interpret the universe either in its smallest or its greatest aspects as a sort of mechanical phenomenon in the way our mid-Victorian ancestors would have interpreted it. We look at one end, the smallest things we know of, electrons and protons and we find they must be regarded not merely as hard particles but rather as what the physicists describe as wave pockets. This would be all very well, but the materialist at once asks, "Waves in what?" And the only answer that the physicist has to give is a strange one. It is, waves in nothing at all, because since the theory of relativity has abolished the ether there is nothing left in science in which waves can undulate. Hence, the waves must be regarded as purely mathematical waves. As Sir James Jeans put it, "we can express those waves by mathematical equations, but if we try to go beyond that and express them as waves of something material, we are at once led into a tangle of absurdities and contradictions." And so it seems that in the ultimate analysis the root of all physical phenomena lies in mathematics, the Queen of the Sciences.

POWER PLANT ENGINEERING June 1933

THE QUEEN *of the Sciences*

THE AXIOM "There is no royal road to knowledge" applies more perhaps to that division of the sciences known as mathematics than it does to any of the others. So it has always been and so it is today, but it is more true today than ever before. For mathematics has grown —grown tremendously, so much indeed that no person today could ever hope to know more than a small fraction of the world's mathematics. So vast has been the increase in mathematical knowledge during the past century that few men, the experts and professors of mathematics included, would presume to claim more than an amateur's acquaintance with more than one of the four major divisions of modern mathematics. The field of higher arithmetic alone as it exists today is probably beyond the complete mastery of any two men, while geometry, algebra, and analysis, especially the last, are of even greater extent. As Dr. E. T. Bell, Professor of Mathematics at the California Institute of Technology points out in his delightful little book, "The Queen of the Sciences" if mathematical physics be annexed as a provence of mathematics, a detailed professional mastery of the whole domain of modern mathematics would demand the lifelong toil of twenty or more richly gifted men.

It is quite evident, therefore, that the task of taking the untrained mind, the average mind of the public visiting the Century of Progress, if you please, into the realm of abstract mathematics by means of readily understandable moving exhibits is an undertaking that might stagger any scientist-educator. And yet, this is exactly what has been undertaken at the mathematical exhibit in the Hall of Science at the Century of Progress.

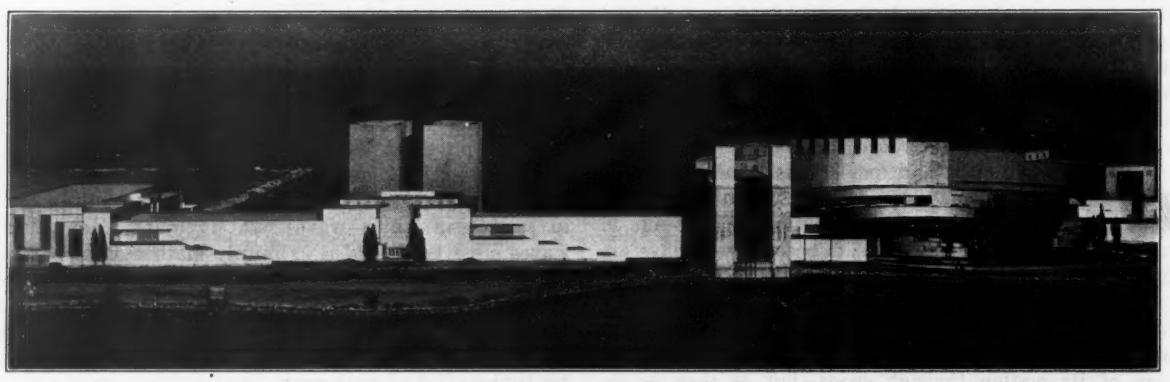
Now, of course, it must not be inferred from this that a mere visit to this section will give the layman a complete course in mathematics—that he will be able to go home and solve a problem in higher algebra or in the differential calculus. That is not the purpose of this exhibit nor indeed of any of the other exhibits in the Hall of Science. But he will go away, provided he is at all open to impression, with a better idea of mathematics, its aim and its general plan. This has not been an easy task but it has been done in an admirable manner.

Acknowledge, to begin with, that of all the sciences, mathematics is the least adaptable to exhibition. It is perhaps the oldest science but it is characterized by its perennial youthfulness. It demands at once a knowledge of some of the most ancient theories as well as the discoveries that were made last week. As Dr. Bell points out, "In theoretical physics it is but seldom necessary to master in detail a work published over thirty years ago, or even to remember that such a work was ever written. But in mathematics, the man who is ignorant of what Pythagoras said in Croton in 500 B.C. about the square on the longest side of a right angled triangle, or who forgets what someone in Czechoslovakia proved last week about inequalities, is likely to be lost. The whole terrific mass of well established mathematics from the ancient Babylonians to the modern Japanese is as good today as it ever was."

The task before those in charge of the mathematics exhibits at the Century of Progress, therefore, was not to attempt to give a course in mathematics to the public, but rather to present a comprehensive view of the subject. The exhibits will be interesting, of course, but what is more important, it is hoped that the method of presentation will influence education.

A broad view of mathematics is seldom if ever given in any of our educational institutions. Of higher arithmetic, even the graduate of a good school will learn precisely nothing. Unless extremely fortunate, he will never even have heard of the theory of numbers. Usually, the student is given training in special tools as he proceeds on his path of knowledge. He progresses from algebra to geometry, from trigonometry to calculus. The last course usually offered is the history of mathematics.

A conception of pure mathematics is seldom given or offered to the undergraduates of our higher institutions of learning. This is unfortunate for it prevents



The Electrical Group

many from pursuing the study of this science because of the interest it holds; not only that, it prevents the majority of mankind ever understanding the work of the modern scientist. As Dr. Bell points out, "without good working knowledge of the differential and integral calculus created by Newton and Leibnitz in the Seventeenth Century, it is impossible even to read serious works on the physical sciences and their applications, much less to take a step ahead. Any normal boy or girl of sixteen could master the calculus in half the time often devoted to stumbling through Book One of Caesar's Gallic War. And it does seem to some modern minds that Newton and Leibnitz were more inspiring leaders than Julius Caesar and his unimaginative lieutenant, Titus Labienus."

It is the hope, therefore, of those who have planned the mathematical exhibits that they will give the public a better insight into the realm over which the "Queen of the Sciences" reigns. And it is an opportune time to do this at this "Century of Progress" Exposition, for it was during the past hundred years that mathematics entered its "golden age." This most prolific period in the history of mathematics had well started by 1830 but the end is not yet in sight. No previous age approaches the past century for the depth and tremendous sweep of its mathematics. The only other centuries at all comparable with the past hundred years are those of Archimedes (287-212 B.C.) and Newton (1642-1727) and these can be compared with the Century of Progress only when generous allowance is made for the difficulties of pioneering.

Mathematics has been divided into four major subdivisions for the purpose of exhibit. These are: 1. Numbers and Algebra. 2. Geometry. 3. Analysis. 4. Applied Mathematics.

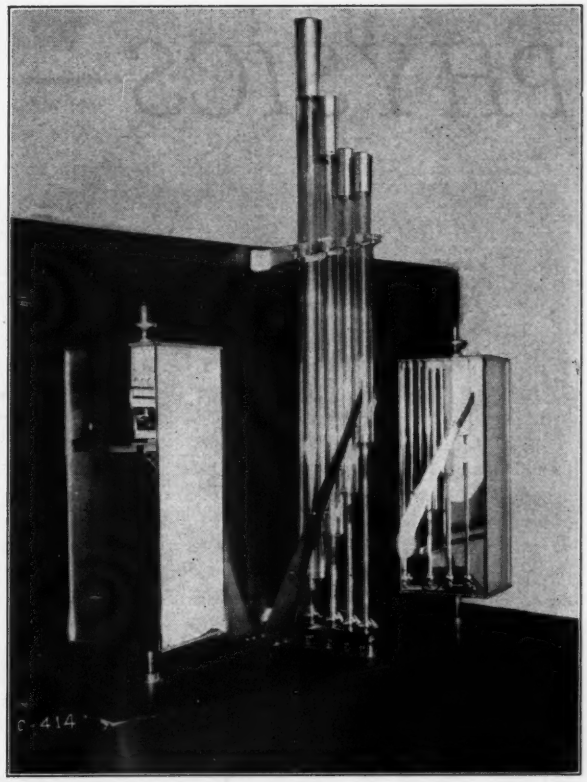
As the visitor enters the North Lobby of the Hall of Science, he will behold in the center of the lobby a large octagonal prism, the design of which will suggest a structure of the ancients. On the north, east, and west faces of the prism are screens on which are projected from inside the prism images of slides which give the progress made through the ages in the four major subdivisions mentioned above.

These slides were prepared by Professor Louis Karpinski of the University of Michigan. They are of unusual interest and over a year was taken up in their making. Their range of interest is wide. The school child of ten will enjoy the spectacle and will sympathize with the little Roman who had to compute with the abacus. The interest of his elders may be taken for granted.

A visit to the geometrical exhibits will be rewarded by a most spectacular display of Pollock's models. Here ever changing surfaces of light will intersect string surfaces in motion. The curves of intersection will stand out as if made of incandescent wires.

Those who have with closed eyes and bowed heads tried to visualize the figures and curves met in higher plane curves will groan in the agony of regret that this presentation was not available in freshman days. Our old friends the "conic sections" have not been forgotten. The ellipse degenerating into a circle and into a double straight line will be shown in a setting of dignified beauty.

Solution of a differential equation of wave motion by D'Alembert in 1747, will be presented as the starting point of radio communication in an exhibit showing the relation of mathematics to the development of radio. Historic apparatus loaned by the U. S. Navy will illustrate radio's progress. A gyroscope compass with "repeaters" will be installed in the Great Hall of the Hall of Science. Instruments used by the Navy in navigation, gunnery and communication will show the indebtedness of our "first line of defense" to mathematics.



One of the Physics Exhibits. Showing how "pitch" is determined by the length of a column of air in an organ pipe.

The Queen exchanges her regal robes for the garments of a servant and is, in another booth, the handmaiden of the sciences. The application of mathematics to Economics is shown in the presentation of the Law of Supply and Demand.

The school boy looking for action and motion may climb aboard a revolving platform near which is the imposing title "The Conservation of Rotational Momentum." The professor of physics will be interested in the derivation of the expression for the rotational momentum which is given in the legend.

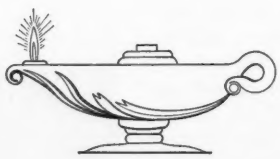
Wherever possible the principles illustrated are connected with the individual who discovered or enunciated the principle.

It is our hope that the visitor will be led to the view that "the deliberate attempt to create something of immediate utility leads as a rule to shoddy work of only passing value." He will agree with Jacobi that "the true end of mathematics is the greater glory of the human mind."

If this presentation of the basic sciences fulfill expectations, it is not unreasonable to think that although there may be no Royal Road to knowledge, at least there is a road, parts of which are broad highways at A Century of Progress.

POWER PLANT ENGINEERING June 1933

PHYSICS—Modern Genie



PHYSICS IS THE ALADDIN'S LAMP which during the past century has remade the world. It has brought electric power into home and factory to do the work of a million slaves; it has given us light without flame, heat without fire, it has enabled us to talk across oceans and to fly swifter than eagles. Without the fundamental knowledge physicists have obtained about the various kinds of energy and about the constitution and properties of matter and electricity the remarkable achievements of most modern inventors and engineers would have been impossible.

Consider, for instance, the development of the electrical industry. It was the discovery by Oersted at Copenhagen of the magnetic effect of an electric current and the subsequent discovery by Faraday of the creation of electric currents by a changing or moving magnet that started the development of electromagnetic instruments and machinery which has given us the modern telegraph, telephone, electrical lighting and electrical power industries.

Likewise the mathematical researches of Maxwell led to the experiments of Hertz and Lodge, which Marconi extended to establish wireless communication first to ships and later across the Atlantic and to the antipodes. Study of conduction of electricity through vacuum tubes led to the development of modern valve tubes which are essential parts of modern radio broadcasting and receiving equipment.

In spite of its fundamental importance, Physics is studied by relatively few, because it is generally considered to be a dry and difficult subject. While it is true that mastery of physical principles sufficient for the solution of practical problems requires a knowledge of mathematics and intensive study, the phenomena and relations upon which many important technical advances have been based are so simple they should be familiar to all.

And they should be familiar to all. There is absolutely no reason why, in a civilization which is based upon the use of machines, people should be unfamiliar with the underlying principles upon which machines operate. Yet there are many people in the world today —people supposedly educated who haven't the slightest idea of how an electric motor operates, why gases exert pressure when the temperature is raised, or how the electric refrigerator in their kitchen is able to keep food cool and fresh on a hot day. They use these devices, indeed they feel that they cannot do without them, yet few know anything about their operation.

Perhaps you will ask, what difference does it make whether they know or not if they do not care to know? Little, probably, to the world at large, for the real scientific knowledge always has been and probably always will be in the hands of a few, but to themselves it could make considerable difference. Certainly the knowledge of how a vacuum tube in a radio set operates should furnish at least as much satisfaction to an individual as being able to translate a paragraph of Latin or Greek or French into English. An intimate knowledge of the world in which we live would seem should be at least as important as the details of a dead language and far more interesting.

And so, to a large extent, it is the aim of the science exhibits at the Century of Progress to create a greater

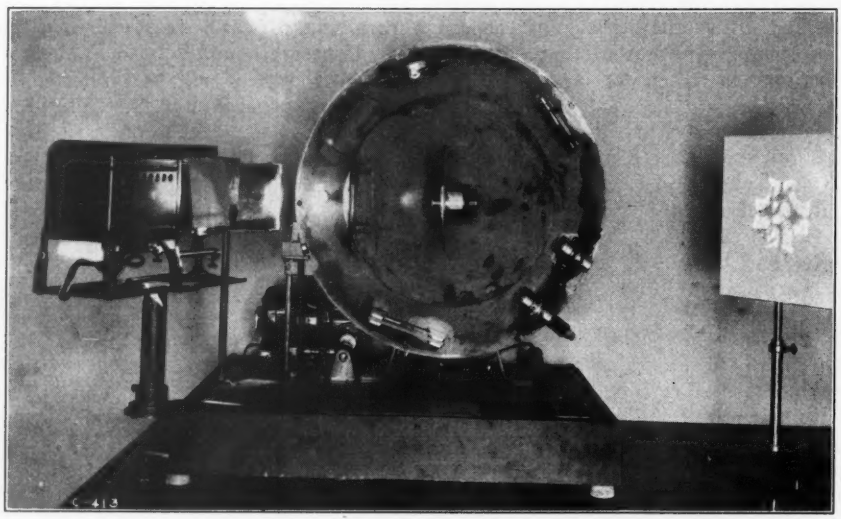


Fig. 1. This exhibit shows the action of polarized light in passing through transparent material under stress. As the circular disc revolves, the beam of polarized light passes successively through the various "examples" of material under stress.

e of the Lamp

Fig. 2. The Electrical Building

interest on the part of the public in scientific matters, to instill a greater appreciation of the beauty in nature's workings. To this end, a series of automatically operating exhibits have been specially designed and constructed to demonstrate to the millions of visitors, in a clear and interesting way, many of these fundamental phenomena and relations. These exhibits are placed on the main floor of the Hall of Science just north of the Great Hall.

Arrangement of Exhibits

The ninety exhibits comprising the physics group are arranged in sequence so that when seen in proper order they are equivalent to a series of experimental lectures covering the most interesting and fundamental physical phenomena. Insofar as possible they are arranged in the order of an ascending frequency scale, beginning at one end, with molecular physics and sound, and proceeding upward through electrical frequencies, to radio, light, X-rays, radium rays, and ending with the highest frequencies known, those of the cosmic rays.

The first group deals with Molecular Physics, the expansion of gases and vapors, evaporation, refrigeration, surface tension and crystal structure. The second group explains the nature of sound, including musical sounds and speech. The third group, beginning with a diorama of Franklin and his kite, shows magnetic effects and will lead from the fundamental relations between electricity and magnetism to the dynamo, transformer and motor. Group four explains the valve tube and shows how it is used in radio. The fifth group shows beautiful effects produced with light, which demonstrates its nature and properties.

Lastly, a group of exhibits shows various types of rays, including cathode, canal, x-rays, radium rays and cosmic rays.

The exhibits are placed on tables 5 ft. high so that all who pass in front of each exhibit may see it before going on to the next. They are clearly numbered so that they can be seen in proper sequence, and placards are to be provided which can be read 10 ft. away.

The sequence of exhibits as pointed out endeavors to conform to the ascending scale of frequency or of decreasing wave length. To show the relations of these wave lengths, there is exhibited at one end of the Hall of Science a large chart, showing the scale of lengths in the universe. This chart is not only instructive but ornamental as well, for the values when listed in proper sequence form a pleasing geometrical design. It is not generally known, but it is a curious fact that man is just about halfway between the largest and the smallest object in the universe. He is 10^{20} times smaller than the Milky Way in which he lives and 10^{18} times larger than the proton out of which all matter is made. So if we list the largest figure calculated by man, the diameter of the Einstein Universe, in meters, at the top of a column, we have the figure 1.9 with 25 ciphers behind it. Below this we list the distance of the furthest spiral nebula, 1.3 and 24 ciphers. So we proceed listing incessively such entities as the Milky Way's diameter, the distance to the nearest fixed star, the diameter of the solar system, the radius of the sun, the earth, the N. Y. to San Francisco Highway, the lowest sound wave, until we come to man, 1.72 meters in height. From man we proceed downward, listing the highest sound wave, the smallest visible particles, the red light wave, the average path of the hydrogen particle, and so on until we reach the nucleus of the hydrogen atom 2×10^{-18} meters in diameter. Thus a chart is made which is at once interesting and ornamental.

It is, of course, impossible in an article of this length to describe the various exhibits in detail. All we can do here is to indicate their nature and what they are expected to teach the visitors.

For instance, how does the air in tires hold up so

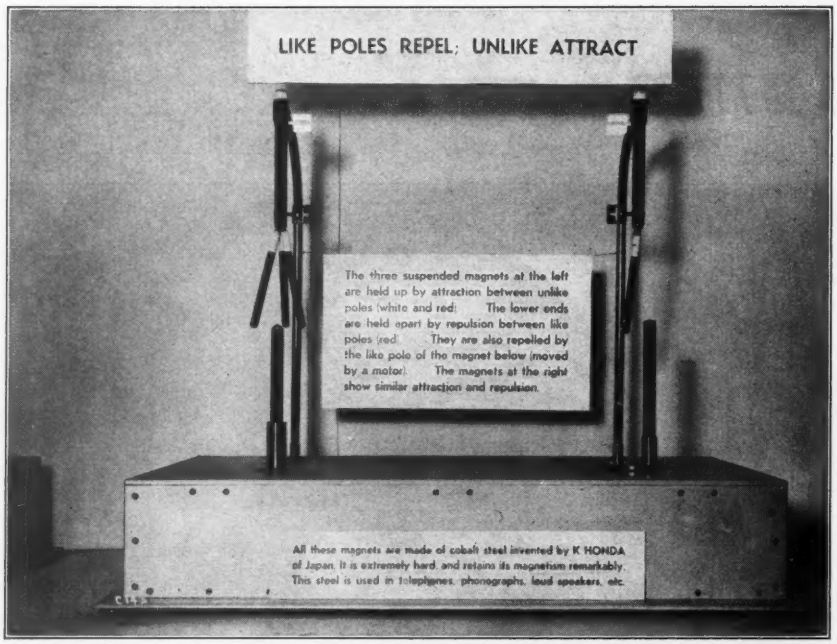

LIKE POLES REPEL; UNLIKE ATTRACT
The three suspended magnets at the left are held up by attraction between unlike poles (white and red). The lower ends are held apart by repulsion between like poles (red). They are also repelled by the like pole of the magnet below (moved by a motor). The magnets at the right show similar attraction and repulsion.
All these magnets are made of cobalt steel invented by K HONDA of Japan. It is extremely hard, and retains its magnetism remarkably. This steel is used in telephones, phonographs, loud speakers, etc.

Fig. 3. An exhibit showing fundamental principles of magnetism. This is one of a series of exhibits of this character, all showing principles of magnetism.

much weight? Why does steam exert such great pressure when in contact with heated water? How can electric power such as is used to heat electric irons and toasters produce "cold" in refrigerators? Why are water drops round and why are crystals regular in shape? These questions, to be sure, are simple enough to engineers but to the general public they are mystifying. Thus, the exhibits on Molecular Physics are designed to answer them, as simply and comprehensively as possible. They not only demonstrate the pressures exerted by compressed air and steam, but include a working model with steel balls instead of molecules showing how the pressure of a gas is due to bombardment of the walls by molecules which have the speed of rifle bullets. The manner in which this is done is extremely ingenious. A number of steel balls are placed on a gently sloping surface so that they normally rest against one prong of an electrically driven tuning fork which forms the lower side of the area in which the balls are placed. As the tuning fork is set into vibration, the balls are violently displaced, the violence and distances to which they are thrown increasing as the frequency and amplitude of the fork is increased. In this way the balls are made to occupy an area much larger than that which they occupy when at rest. This demonstrates the expansion of a gas with constant pressure. The image of the balls is reflected by means of a system of mirrors to a vertical screen.

An intermittent fountain, a balloon alternately expanding and collapsing under a bell jar, an engine with glass cylinders operated by electrical heat, icicles formed by evaporation, drops four inches in diameter, an umbrella shaped water film and other exhibits will all be interesting and instructive.

Sounds are of great practical importance whether classified as speech, music, jazz or noise. The exhibits in the "Sound" section explain how sounds are produced, how sound waves travel, when resonance occurs, what determines the pitch of a sound, how speech sounds differ and how talking films reproduce sounds. To make these things clear to the layman every modern principle available to science has been employed. The visitor will see a large tuning fork apparently vibrating very slowly through a large amplitude; he will hear four tubes of different lengths singing in succession and will see at the same time the images of the vibrating flames within the tubes, reflected by a rotating mirror as flaming saw teeth; he will see a magnified image of the sound track on a movie film and at the same time hear the corresponding sound. In the final exhibit of this group, speech sounds will be transmitted on a light beam which the visitor may intercept if he wishes.

Electricity, our marvelously convenient and efficient servant today, was merely a curiosity a hundred years ago. The great discoveries on which is based the development of the great electrical industry of today are demonstrated in a series of exhibits which will explain the fundamental principles of the dynamo, the transformer and the motor. Since these devices operate by virtue of the interaction between electric currents and magnetic fields, exhibits show the principles of electromagnetism. One exhibit for example demonstrates Oersted's discovery. Here a dip needle on glass and illuminated from behind is deflected as a vertical wire carrying 40 amperes is moved close to the needle and then away. The effect of introducing an iron core into a solenoid also is demonstrated.

Electrical engineers and power plant men will be interested in the exhibits showing generator and transformer action. There is a six-pole generator with a single coil on its armature and a neon glow tube across the ends of the coil giving an indication of the instantaneous voltage generated. By means of a collector ring and a commutator both alternating and direct current are obtained from the generator alternately. In another exhibit a slowly rotating magnetic field is produced by connecting each phase of the field of an a.c. motor to direct current source in succession, lighting lamps opposite the corresponding poles in synchronism. The armature is a celluloid disk carrying a diagram of the magnetic

field and four small compass needles. In still another exhibit, a three phase a.c. motor with armature carrying a single coil including a section of nichrome wire is shown. When a brake holds the armature at rest, the induced current heats the wire red hot. When the armature is free, the slip is shown by stroboscopic illumination.

Radio broadcasting is the modern miracle, undreamed of 30 yr. ago. The key to the mystery is the valve tube. Exhibits demonstrate the action of the filament, grid and plate and show how sounds are amplified and how the continuous oscillations necessary for broadcasting are produced by use of such tubes. Spark signal sending and carrier wave sending are demonstrated.

By use of lenses in telescopes and microscopes the eye is enabled on the one hand to see glories of the heavens, otherwise invisible, and on the other to study the minute structure of metals and microbes.

The exhibits showing the refraction of light rays are cleverly worked out and of course are entirely automatic in their operation. This, of course, is true of nearly all the exhibits—movement is a part of all of them. In the refraction exhibit a converging lens, a diverging lens and a prism are all mounted on a revolving disk which is so placed with respect to a beam of light that the light passes successively through each of the three elements, showing the effect of each in a simple and beautiful manner. The principles of reflection are shown in the same way.

The beautiful colors of soap films tell us that light is a wave motion similar to radio and the frequency of vibration of green light is higher than that of red. An exhibit shows in a simple way how we know that the wave length of light is about twenty millionths of an inch. An application of the use of polarized light is shown in a model which passes polarized light through transparent models of gears, beams, etc., so as to project images of the strains in these models on a screen. Other exhibits show beautiful colors produced by sending polarized light through a sugar solution or a crystal. Light from an arc and from neon tubes is analyzed into the component spectrum colors.

The electric eye, the photocell, is a modern genie produced by scientific research. Exhibits show the fundamental phenomenon and also applications to the reproduction of sound.

Physicists discovered the electron and the proton, building stones of all atoms. These tiniest of particles cannot be seen individually, but when given speeds of 100 to 100,000 mi. per sec. they are called cathode, canal, alpha or beta rays and produce effects which can be seen. Exhibits show luminous effects due to cathode and canal rays in vacuum tubes, also tracks of single alpha rays from radium, and the properties of x-rays which are produced when cathode rays strike a target. Finally a "hodoscope" designed by Dr. Johnson of the Bartol Institute shows the paths of individual cosmic rays by means of flashing neon lamps.

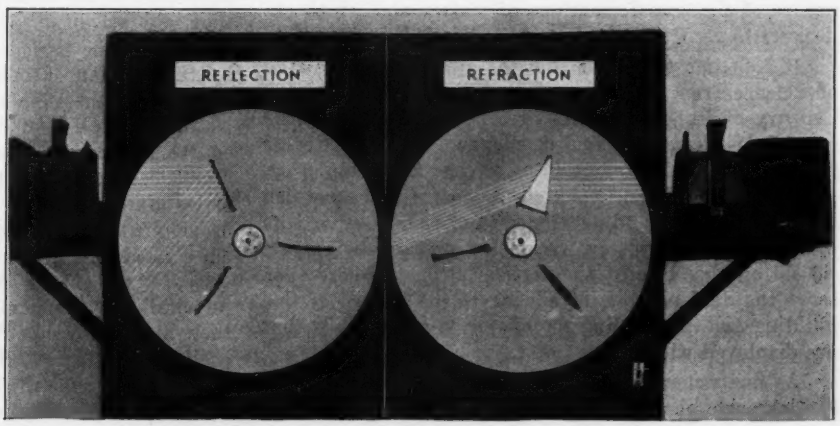
Applications

The exhibits in the Physics Section in the Hall of Science demonstrate mainly fundamental phenomena and relations. Numerous industrial applications of these scientific discoveries will be found in various other parts of the Exposition, for example in the liquid air and electric furnace exhibits of Union Carbon and Carbide Co., in the electrical exhibits of the General Electric Co., Westinghouse and others, in the communication exhibits of the Bell Laboratories and R.C.A. and in the transportation exhibits. In fact very few of the industrial exhibits will not contain application and illustration of one or more physical principles.

Some of the social consequences of the industrial progress made possible by advance in scientific knowledge, will be shown in the Hall of Social Science. Ours is a much smaller world than that of one hundred years ago, due to progress in communication and transportation; industrial methods and organizations have been profoundly changed; even politics has had to adapt itself to the radio.

The greatly increased knowledge as to the ultimate nature of matter and energy and the astronomical discoveries, made by the application of physical instruments and methods, as to the size of the universe, have had important theological and philosophical effects which are perhaps not less important than the social and industrial changes resulting from the scientific progress of the past century.

To see each of the ninety physics exhibits go through its cycle of operations will take a visitor about two hours. In this time, no person can acquire a knowledge of all the physical principles demonstrated by the exhibits. However, it is hoped that everyone will learn some of these principles and will come away with a better understanding of the fundamental phenomena underlying some important industrial developments and a fuller appreciation of the debt of our present civilization to Basic Science.



An exhibit showing the principles of reflection and refraction. At the left a beam of light is reflected successively by a plane mirror, a convex, and a concave mirror. At the right the principle of refraction is shown similarly by means of a prism, a diverging and converging lens.

CHEMISTRY — Economic I

ONE ORDINARILY does not associate politics and economics with the science of chemistry but a deep study of the history and application of this science reveals not only an association but a very definite and close relationship between it and the political sciences. Dr. William J. Hale, director of organic chemical research at the Dow Chemical Co., discusses this in his recent book "Chemistry Triumphant" in a very interesting manner. Civilization, says Dr. Hale, finds itself on a chemical threshold. Only of relatively late years has nature been revealed and only now are we beginning to have a true insight into what chemistry means—to industry, to mining, to agriculture, to manufacture, to transportation. And so, he urges us to study chemistry, to accept the chemical view, for nothing can ever stay the march of its progress. Chemistry brings the second great world revolution. The marshalling of forces from the bowels of the earth—coal and water—into steam power brought on the first great revolution. Today we are in the second world revolution; the forces from out of the heavens—nitrogen and oxygen—have been made to yield a new power. Indeed, it is not generally known that one chemical discovery made the outbreak of the World War possible in 1914.

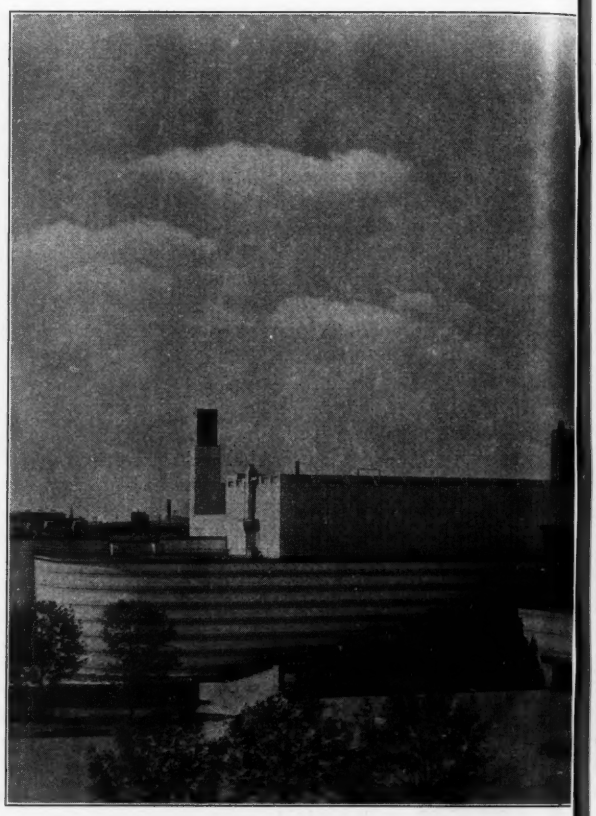
Aside from its growing economic importance, chemistry is important because it deals with the basic processes of life and the transformations of matter. Biology is largely concerned with chemical processes. In every one of us every single moment, millions of chemical transformations sustain our life and make possible our multifold activities. Further, there is scarcely an article about us which is not the product of some industry dependent upon transformations of crude materials taken from many sources.

The production of electric power from fuel involves chemical transformations, for combustion of carbon and hydrogen in coal and oil with oxygen in the air is nothing more than a chemical reaction.

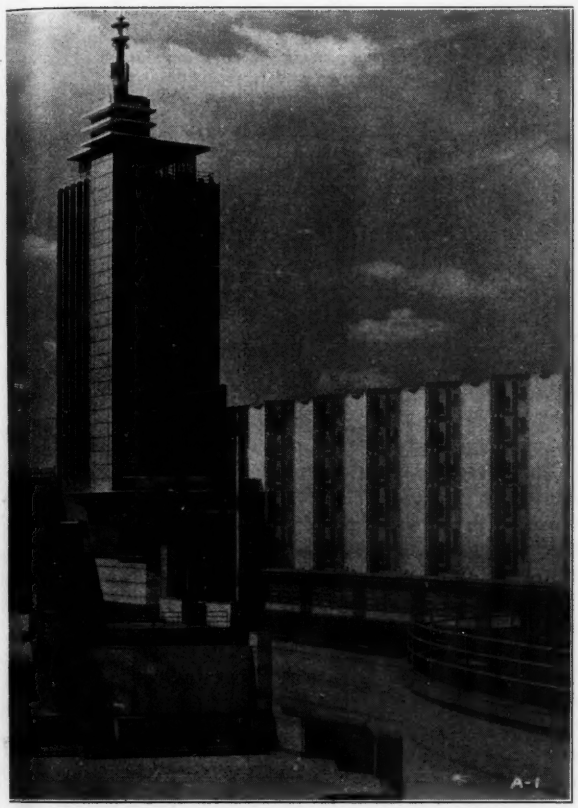
These are instances of our close association, our dependence upon transformation of matter, and serve to indicate the importance of chemistry in our civilization. For chemistry is the science which explores the nature of the transformations of matter and which endeavors to recognize the laws governing these processes.

It is fitting, therefore, that the approach to the Hall of Science from the great plaza facing the lake at the Century of Progress should present to the visitor some concept of the phenomenal development of chemistry as a symbol of the contribution of science to human progress. A series of ten strikingly beautiful murals which depict the growth and development of chemistry and its application to industry, commerce and medicine, are placed on this face of the Hall of Science where they serve the dual purpose of adding to the beauty of this building and introducing the visitor to the exhibits that are displayed within.

As one enters the great hall of this building from the lake side, the attention is at once focused on an imposing model of the periodic table of the chemical elements which occupies one end of the hall. This exhibit by virtue of the fundamental scientific principle which it depicts, by its central location and by its unusually striking design, has rightfully been called the central feature of the entire Exposition. The periodicity of the elements, which this model portrays, is one of the most fundamental concepts of modern chemistry. By periodicity is meant the surprising regularity in the properties of the elements which becomes apparent when they are arranged in the order of ascending atomic numbers. The periodic law was first expressed in 1869 by the Russian chemist, Mendeléeff. At that time the structure of the atom as we know it today was unknown. Nothing was known of protons and electrons and, of course, nothing was known of atomic numbers. But Mendeléeff recognized the relationship between the properties of the elements when they were arranged in the order of their increasing atomic weights, and so he enunciated his famous law which, in his own words, stated, "all of the properties of the elements, both physical and chemical, vary as a periodic function of their atomic weights." With the aid of this great generalization, Mendeléeff was able to predict the occurrence of three still unknown elements, their atomic weights, where they would be found, and what their



Dictator of the Future



properties would be. Within less than 20 yr. all three of these elements were discovered.

With the further development of atomic research and with an increasing knowledge of the electrical structure of matter it was found that the atomic number rather than the atomic weight determines the position of an element in the periodic table, but that did not detract from Mendeléeff's great discovery. This is the basic law of the science of chemistry, and it has been of far reaching importance in its development. At first the reason for the law was unknown but today the structure of the atoms furnishes the explanation of the relations expressed in the periodic system.

For these reasons, then, the model of the periodic table is fittingly impressive and imposing. The exhibit as a whole is approximately 30 ft. high and 25 ft. in diameter. The lower part consists of a beautifully designed model of a periodic table of the chemical elements, in which is displayed in proper sequence a sample of each of the elements. In each case the most important source and the most important use of the element are also presented. The material for this exhibit has been assembled from all over the world—and in many instances very rare and beautiful specimens have been obtained. To emphasize the fact that the 92 chemical elements comprise all that we know of the earth, a ten foot revolving globe surmounts the periodic table. On this globe will be indicated the location of the most important sources of the more common elements. The entire exhibit is so designed and so lighted that despite its enormous size, every visitor may view at close range any part of the display.

To fully appreciate its significance one should be somewhat familiar with the modern electrical theory of matter—how the addition of a single electron changes the properties of one atom from another. Chemistry more and more is destined to be interpreted electrically, and electrical symbols are beginning to appear in our chemical equations even now. Hydrogen, for example, because its nucleus consists of a single positive charge is represented by the symbol H^+. The atom of oxygen consists of a nucleus with eight electrons around it, two in an inner orbit and six in an outer orbit. It so happens, however, that the outer orbit is unstable, with six electrons—it requires eight. Hence the atom of oxygen tends to combine with elements having an excess of electrons. Because of this we say it has a negative valence of two and it is written $O^=$. Sodium on the other hand has an electron too many—it tends to lose an electron. Thus we say it has a positive valence of one, and is written Na^+. Similarly all elements can be written in terms of their valence electrons. Magnesium has a positive valence of 2 and is written Mg^{++}. Combined with oxygen to form magnesium oxide we get $Mg^{++}O^=$.

From this it is evident that modern chemistry is closely related to electrical theory and also that the periodic table is extremely fundamental in chemistry.

Surrounding the model of the periodic table are presented the chemical exhibits, arranged in a series of connected stories, each story told by a number of dynamic exhibits displayed in a logical sequence.

The guiding principle in the preparation of these chemical exhibits has been that the exhibits must be not only interesting, attractive and entertaining to those who are merely curious, but must also be instructive to those who come to learn. In addition, the exhibits have been constructed in conformity with a scientific accuracy which will enable them to withstand the rigorous scrutiny of the trained scientist. They are not the usual trade-show or museum type exhibit, but are dynamic models which show *principles* and *processes* rather than *products* and *equipment*.

The preparation of chemical exhibits presented many problems entirely different from those encountered in the preparation of other technical exhibits. There are museums throughout the world in which are displayed excellent exhibits in astronomy, geology, physics, biology and medicine; but nowhere is there a really effective or adequate exhibit in chemistry. It is not difficult to find a reason for this. For instance, in the preparation of a dynamic exhibit in physics, a convenient source of electric current is the principle requirement. To show a chemical principle, one must supply various forms of energy together with chemical reagents which

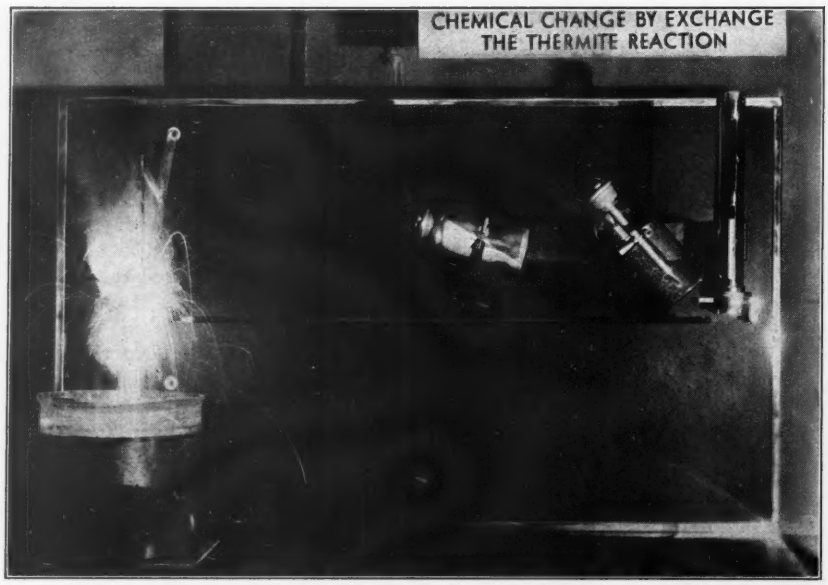


Fig. 2. One of the Chemical Exhibits, showing the Thermite reaction. At intervals a "charge" is taken from the bottles of aluminum and ferric oxide at the right and this is ignited by an electric spark at the left. The exhibit is entirely automatic in operation, and is designed to operate continuously 12 hrs. or more a day for 5 months. Electric motors actuate the model.

are used up and must be replaced. Refuse and by-products must be removed. Fumes are produced and proper ventilation must be installed to remove corrosive or poisonous gases. Great care must be used to obviate the danger of fire and explosions. All of these and many other difficulties must be surmounted before one can build a dynamic chemical exhibit. It is one thing to heat mercuric oxide in a test tube and show that mercury and oxygen are formed, but it is quite another thing to construct a dynamic exhibit which will automatically perform this reaction without fail once a minute, ten hours a day, for 150 days.

In presenting chemistry to the lay public, for one must remember that these exhibits are prepared so that they will be intelligible to the average man and woman —those responsible for the exhibits have deviated from the usual methods of teaching chemistry in subdivisions such as inorganic, organic, physical, photochemistry, etc. Rather chemistry is presented as the fundamental science of the transformation of matter and the laws which formulate these transformations. Following this are shown the methods and tools of chemistry and how, by means of these, the chemist has developed our natural resources and transformed them into the necessities of our daily life.

The first unit in the chemical exhibits deals with chemical changes and the various ways that they may be produced. Here, among others, may be seen such striking exhibits as the burning of iron, streams of liquid fire, metallic mercury produced from a clear solution, and fire started with water. These exhibits are spectacular, but since they are designed to illustrate definite types of chemical changes rather than to mystify the layman, an accurate explanation accompanies each one.

These exhibits on chemical changes are followed by exhibits on catalysis, designed to show methods by which the speed of chemical reactions (or changes) may be

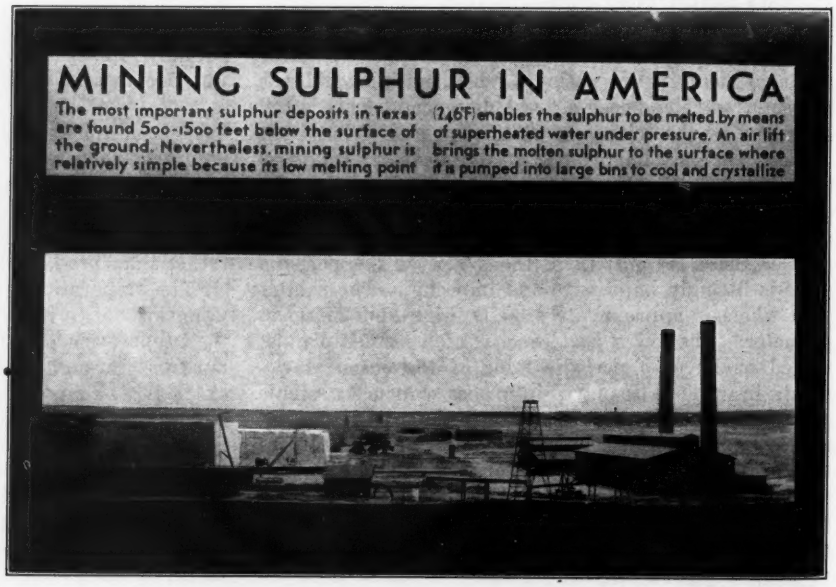

MINING SULPHUR IN AMERICA
The most important sulphur deposits in Texas are found 500-1500 feet below the surface of the ground. Nevertheless, mining sulphur is relatively simple because its low melting point (246F) enables the sulphur to be melted by means of superheated water under pressure. An air lift brings the molten sulphur to the surface where it is pumped into large bins to cool and crystallize

Fig. 3. One of the numerous dioramas. This one shows the mining of sulphur as it is carried on at the present time. The diorama is really a 3 dimensional picture, consisting of models built in perspective in the foreground which merge into a painted background in such a way that an illusion of reality is obtained.

varied. The central feature of this unit is the story of sulphur. A dynamic display depicts in miniature the actual mining of sulphur, its conversion to sulphur dioxide, and finally, its transformation to sulphuric acid by the catalytic contact process. In the contact process is shown the Cottrel precipitator by means of which the finely divided, colloidally dispersed sulphuric acid is quickly changed from a fog to a heavy liquid. This leads directly into the story of colloids.

The unit on colloids presents to the visitor some of the interesting information which the chemist has gained from the study of this class of substances. Colloids are mixtures in which one substance in very finely divided form is dispersed or suspended in another. Clouds are suspensions of liquid in air, many paints are colloidal suspension of solids in liquid, mayonnaise is a suspension of one liquid in another. The study of the behavior of colloids has had a profound effect upon the scientific concept of matter. In this unit one can see a beautiful demonstration of Brownian movement—the continuous zig-zag motions of colloidally dispersed particles as a result of molecular motion in the medium. There are also shown exhibits on the preparation and precipitation of red and blue colloidal gold, the purification of water by the precipitation of colloidally suspended impurities, and a complete operating exhibit on ore flotation which shows the separation of gold, lead and zinc from the crude ores.

The fourth unit deals with the chemical treatment and refining of oil. A complete miniature refinery, made largely of glass, has been constructed; and the refining processes, beginning with the fractional distillation of crude petroleum and ending with the highly purified products, may be seen in operation. A voice will describe and explain each step of the process. Demonstrations of some of the characteristic properties of oils will be included. The entire display is presented with the idea of showing the result of the application of theoretical knowledge to a practical problem.

A fifth unit presents the transformation of rubber from the crude milky latex to the finished product. In this exhibit one can see rubber latex flowing from a real rubber tree which has been brought here from Africa. Dynamic exhibits will demonstrate the continuous coagulation of rubber with formic acid, the electroplating of rubber, and the process of vulcanization. The nature and use of accelerators, pigments and anti-oxidants will also be shown.

The story of air is introduced by means of a diorama of Lavoisier in his laboratory. This chemist proved that oxygen, one of the constituents of air, is used by the body to support life. In addition to exhibits illustrating the composition and properties of the constituents of air, this unit contains other exhibits which show various methods for liquefying gases by cooling, by increasing the pressure and by rapid expansion of the gas. In a lecture room on the ground floor of the Hall of Science there will be continuously demonstrated the properties of liquid air and of some of the striking effects of the extremely low temperature which can be produced by means of liquid air.

Of particular importance is the unit on coal tar, designed to show how the chemist has developed a by-product—which manufacturers formerly paid to have removed as refuse—into some of the most valuable products of our present day. From coal tar are prepared

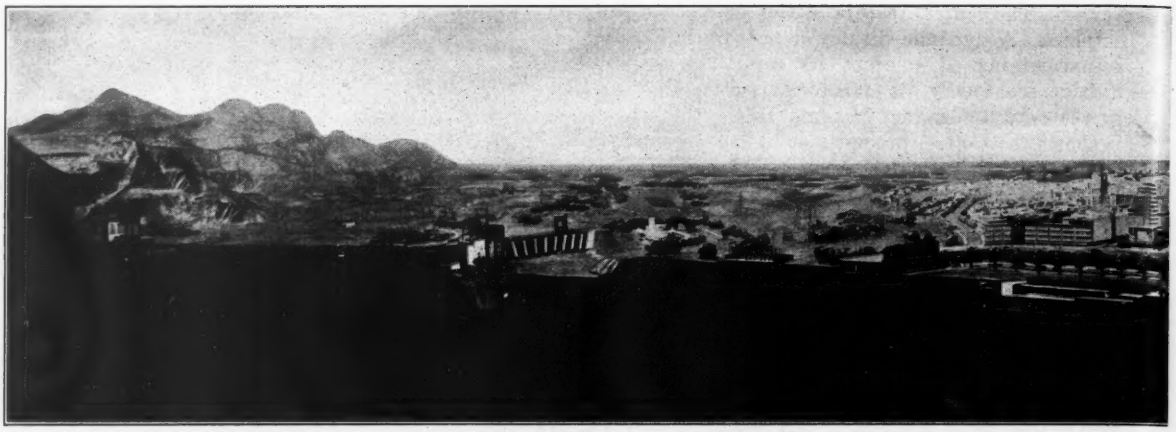
Fig. 4. In the biological group, this complicated mechanical affair will simulate the growth of a twig during a year's time in 15 seconds.

our beautiful dyes, our medicinals, our perfumes, our explosives and our plastics. The feature of this unit is an exhibit showing the processes involved in the manufacture of Bakelite.

An outstanding feature of the section dealing with electrochemistry is a large automatically operating exhibit which demonstrates the process of chromium plating. The visitor will be presented with a chromium plated souvenir which he has seen pass through the plating process. Electric furnaces of the arc, resistance and induction type, and some of the effects of the terrific heat which they generate will be shown.

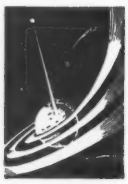
Finally is shown the story on the chemistry of food and nutrition. This exhibit is unique. A 10 foot robot will give a 20 minute lecture on food chemistry and nutrition, illustrating his lecture by means of demonstrations which he operates, a number of static exhibits to which he points, and finally a demonstration of the processes of digestion on himself by means of a moving picture projected from behind on his own front. The robot describes the constituents of food—the proteins, carbohydrates, fats, vitamins and minerals. He demonstrates the function of each and how they are broken down or digested in the body to simpler products which can then be assimilated by the body tissues. He also describes the functions of the hormones or chemical messengers in our bodies.

In addition to these basic science exhibits a number of the chemical concerns are presenting striking exhibits showing their contribution to the industrial and commercial development of the scientific principles demonstrated in our basic science exhibits.



ELECTRICITY AT WORK, A 90 FT. DIORAMA, SHOWS THE COM

ELECTRICITY — The



A CENTURY of Progress is a gaudy tapestry woven from countless threads on a warp spun from thousands of human lives. It was woven on the loom of Power supplied by the conscious or unconscious efforts of the millions who have lived since the dawn of history. Intuitively, blindly they have struggled in the darkness turning the treadmill by brute strength. Here and there an individual struggles up on their shoulders, devotes a lifetime of sacrifice and effort to helping those generations who will follow, and then becomes a single cord in the complications of history.

Occasionally an individual through a fortunate combination of circumstances or a superior intellect will forge far ahead of all the others and weave his life into the woof where he forever remains in the consciousness of posterity. The work of Volta, Faraday, Ampere, Ohm, Henry, Morse and Bell and Tesla are names that cannot be forgotten as long as electricity is used.

More modern names, such as Edison, Thompson, Rice, Brush, Steinmetz, Sprauge, Emmet, Whitney, Coolidge and Langmuir traced in light at the General Electric exhibit and Lamme, Westinghouse, Conrad, Slepian and Skinner of Westinghouse are familiar to all those connected with the electrical industry. Nor can we overlook the names of Watt, Perkins, Corliss, De Laval, Parsons, Curtis, Francis, and Diesel as some of the men who furnished the motive power which made electricity a commercial success.

FIG. 1. DIORAMA OF BENJAMIN FRANKLIN AND HIS SON FLYING HIS FAMOUS KITE

But, today we are far from the ultimate solution of this problem. Over thirty years ago Edison confidently predicted that the direct conversion of coal to electricity would be an accomplished fact within a few years. Although this has actually been done on a small scale it is still far in the future commercially, convincing evidence that even the intellect of great men cannot pierce the veil that hides the future.

The Future Cannot Be Predicted

Speculations are futile for we are living in a critical period of electrical history. Even prophecy is of no avail for future developments are literally in the "laps of the gods" and in the past the gods have shown a lively interest in making man do his own work in nature's treasure hunt.

Pursuing electricity through the molecule and atom down through the electron in search of the universal building blocks of the Greeks, the modern investigator finds a mathematical formula. The leaders of necessity have turned from the physical to the metaphysical and have completed a 2000 yr. cycle which brings the scientific world of today side by side with the speculative philosophy of the ancient Greeks. Today the electron is thought to be the practical building block of the universe—the atom of the Greeks. Beyond that we know no more than they did although we have put many of the by-products of this search to material advantage.

Electricity in the form of magnetism was known from earliest time, perhaps the earliest reference is the Myth of the Goddess of the North Star who, falling in love with a mortal, Siderite, came to earth only to be spurned by him because of love for his brother Sidere. In her wrath she transformed the brothers, one into lodestone and the other into iron.

Lodestone is a native compound of iron which acts

PLETE GENERATION, DISTRIBUTION AND USE OF POWER

Silent Partner of Industry

as a natural magnet, will attract iron and used on a floating piece of cork it formed one type of early compass. As early as 600 B. C. the electrical action of amber rubbed with fur was demonstrated by Thales but, in the centuries following, contributions to man's knowledge of electricity were few, being confined chiefly to the development of the compass. In 1600 all available knowledge on the subject was gathered together by Gilbert in his book De Magnete.

From this point on investigations were carried on in a much more scientific manner. The first significant development was the invention of the voltaic pile by Volta in 1799. This originally consisted of a pile of silver and zinc discs separated by pieces of wet and salted cloth but was later changed to copper and zinc in dilute sulphuric acid.

Light—the Universal Urge

As the first source of electricity in any considerable quantity this made possible the discovery of electro magnetism. Davy used a cell of this type to demonstrate the heating of wires by electricity in 1802 and in the first arc light demonstration in 1809. Commercial applications of course demanded a better means of current supply which was furnished by a series of discoveries beginning about 1820 and ending finally in the dynamo. In 1820 Oersted accidently discovered electromagnetism by noting that current flowing through a wire deflected a compass needle. Following this work up, Ampere discovered that current flowing in a coil gave it magnetic properties and he formulated fundamental laws regarding the direction of flow and needle deflection. Five years later Ohm formulated his well known law which, however, was not fully accepted until 1841.

Thus the birth of the electrical industry is dated about 1820-30, usually in the work done by Faraday which although paralleling that of other investigators was better coördinated and led directly to the development of the motor and dynamo. In 1821, Faraday discovered that a conductor carrying a current in a magnetic field tends to move—the principle of the motor. Ten years later he discovered, almost simultaneously with Henry, that a conductor cutting a magnetic field develops an electric current—the principle of the dynamo. A model of Faraday's original dynamo is shown in Fig. 2.

From this point on the development of the dynamo progressed rapidly in the hands of such men as Pexii, Sturgeon, Hjorth, Clarke, Wheatstone, Siemens, Nollet and Gramme. The development of the commutator, electro instead of permanent magnets, self excitation and ring wound armatures, added to the utility of the machine until by 1872 the dynamo had all the features of a modern machine.

Lighting was of course the primary interest at this period and by 1860 the arc lamp was fairly well developed and the incandescent lamps were being experimented with in all parts of the world. Finally about 1879 Edison in America and Swann in England developed successful incandescent lamps which gave a great impetus to electrical development. The immediate result in this country was the opening of the Pearl Street steam station in New York in 1882 although Edison's first commercial installation was on board the S. S. Columbia. In 1883 Edison patented the three wire system which saved about 60 per cent of copper and greatly facilitated the spread of central stations.

The First Edison Station

Pearl Street had six Jumbo dynamos direct connected to steam engines, each unit being rated at 7200 lamps equivalent to about 540 kw. or 720 hp. Equally important was the opening of the Appleton (Wis.) hydraulic plant in 1881. Pearl Street is generally regarded as the first central station because of its continuous operating record with a successful lighting system. Actually central station arc light systems were in operation before this time in Kansas City and San Francisco, the California company having three 16 light machines operating in 1879 (12 o'clock lights renting for $10 a month).

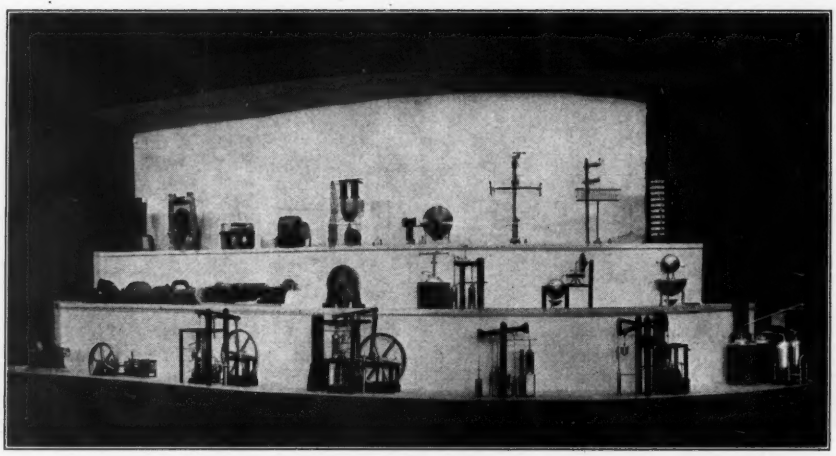


Fig. 2. Historical Power Exhibit

Top Row, Left to Right—Edison, Dynamo, 1879; Gramme, Ring Armature Dynamo, 1871; Pacinnotti, D. C. Dynamo, 1865; Siemens, Shuttle Armature Dynamo, 1856; Pixii, Magneto-Electro Machine, 1832; Faraday, Magneto-Electric Machine, 1831; Oersted, Electro Magnetism, 1820; Ampere, Magnetic Properties of an Electric Circuit, 1820; Volta, Electric Cell, 1800. Middle Row—De Laval, Turbine, 1889; Parsons, Non-Condensing Turbine, 1884; Wilson Radial Flow Turbine, 1848; Dekempelen, Reaction Turbine, 1784; Branca, Impulse Turbine, 1629; Hero Turbine, 120 B.C. Bottom Row—High Speed Engine, 1870-1890; Corliss, Engine, 1849; Woolf, Compound Engine, 1804; Watt, Double Acting Engine, 1782; Watt, Single Acting Engine, 1769; Newcomen, Pumping Engine, 1711; Savery, Pumping, 1698

While direct current was progressing so rapidly alternating current was undergoing experimentation. Perhaps the first successful installation being Dungeness Lighthouse arc lamp installation in 1862. Commutator trouble developing, collector rings were substituted, the resulting alternating current being found satisfactory. The efficiency of machines at this time may be judged by the fact that this machine which required 1.5 hp. to drive it supplied one arc lamp which took about 10 amp. at 45 v.

The obvious disadvantage of direct current for distribution at a distance led to further experiments with alternating current, the first alternator being patented by Ferranti in 1882. Within a few years he was generating and distributing current at 10,000 v. but unfortunately he was far ahead of his time and was hampered by lack of suitable insulation and materials.

Transformer Patented, 1882

Development of alternating current depended upon suitable transformers for it is the ability to step up and step down voltage that gives the alternating current its advantage in distribution. Evolution of the transformer began with Faraday and Henry. Faraday's early experiments were carried out with two solenoids, one fitting the other, Henry's with flat spirals. Faraday later substituted a soft iron ring on which the primary and secondary were wound in a one to one ratio. This ring had the fundamentals of a transformer although Faraday had no conception of the device as for stepping up the voltage.

The transformer as we know it today is, however, a development of the induction coil of Page constructed in 1838 and used with an interrupter. Up to about 1878 the induction coil was used only for sparks but in this year Joblochkoff exhibited at the Paris Exposition a distribution system using induction coils and interrupted current and also alternating current. Apparently, the application of the transformer to high voltage transmission was first applied by Goulard and Gibbs who patented it in 1882 and exhibited it in London in 1883. In their system the transformer primaries were connected in series which gave poor regulation. Parallel connection was suggested by Kennedy in 1883 and the two ideas were combined about 1885 by Stanley in this country and Zipernowsky, Deri and Blatley in Europe.

To Westinghouse must go the actual credit for pushing the development of alternating current in this country in the face of most discouraging opposition from proponents of direct current. Under the patronage of Westinghouse, Stanley in 1885 constructed a transformer at Great Barrington (Mass.) and lighted 150 sixteen candlepower lamps from a distance of half a mile, using a 500 v. primary. From the so-called 16 cp. lamp of that day to the 30,000 w., 100,000 cp. lamp which astonished Mr. Edison in the General Electric Research Laboratories in 1912, meant many hours' work and the combined efforts of many men.

The Motor Preceded the Generator Historically But Was Developed Later

Generators having reached a commercial stage, motors which preceded them historically began to develop. Bailey in 1879 exhibited the first induction motor. By 1890, the polyphase motor was well developed, the Frankfort Exhibition of that year being a highly successful electrical demonstration, the high point of which was the transmission of electricity a distance of 170 kilometers at 8500 v.

From then on the development was rapid and is of course modern history. Alternating current was in the ascent and although direct current continues to be used even today, important developments were in the alternating field. Use of both systems necessitated the development of some means of tying them together. The result was the development of rotary converters, the mercury arc, vacuum tubes and more recently a new rectifier using a revolving arc.

Development of large sized generating units depended not only on electrical developments but on suitable prime movers as well. In 1881 Edison had some difficulty getting an engine to drive his Jumbo generators and although engines of perhaps 10,000 hp. would have been practical it is evident that the development of the industry to 200,000 kw. units would not have been possible without the turbine while the turbine in turn was developed from a background of centuries of prime mover development.

Use of both wind and water are prehistoric. The work of Hero (100 B.c.) on water, hot air, steam and wind motors is well known although after the time of Christ development work lagged. The Doomsday Book (about 1086 A.D.), however, complains of a tide mill in the port of Dover which greatly interfered with shipping so that some use of the ancient device was evidently

made throughout the ages. Aside from the work of Branca, published about 1629, work in steam centered in the engine which receiving an impetus by the work of Watt and reached its highest development under Corliss and Stumpf. Like Ferranti in electricity, Perkins, contemporary with Watt, was ahead of his time and his work with steam pressures as high as 1400 lb. are now largely forgotten.

The first important work on the steam turbine was done by De Laval as early as 1870 as subsequently developed primarily as a drive for his cream separator. The early machines operated at speeds as high as 50,000 r.p.m. and the lack of suitable gears hindered their general application at that time. De Laval also utilized high pressure, high temperature steam in connection with his turbines, records showing pressures of 3420 lb. and temperatures of 750 deg. F.

Parsons developed the reaction turbine (his work beginning about 1883) and in 1889 established his own factory. The roll of investigators include Curtis, Seger, Rateau, Segner and others, the development being relatively rapid after 1900. Two 200-kw. direct current turbine units were installed in New York in 1894. The first central station alternating current turbo-generator was a 1500-kw. machine at Hartford in 1901 although the real start of the turbine was the record breaking 5000-kw. unit installed in Chicago in 1903.

Boiler Development

Turbine and engine development was accompanied of course by boiler development. The tea kettle type of the early Watt era was followed by the Cornish, Galloway, Scotch Marine and modifications of the internally fired and fire tube types. As early as 1766 water tube boilers were built. In 1825 Evans built the first sectional water tube boiler, the first Babcock & Wilcox boiler was patented in 1867 and the bent tube boiler sometime later.

Water wheels well developed during Roman times were greatly improved by Poncelet while the first modern turbine was introduced by Foureyron closely followed by the improvements of Francis in 1847. Development in all sections of this country finally led to the development of the Hercules wheel in 1876, a prototype of modern wheels. The Pelton impulse wheel was invented in the latter part of last century and was followed by the comparatively recent propeller and Kaplan turbines which are still in the active development stage.

Internal combustion engines also played their part in electrical development with a complicated history in all countries from the gun powder engine of Huygens to the first Diesel patents in 1892. Internal combustion engines of both the carburetor and Diesel type are today an important factor in power development, the largest engine of the latter type having reached as high as 22,500 hp.

Developments of the electrical industry are shown in the Hall of Science, and Electrical Building, the major portion being grouped around the Central Station Industries exhibit, Electricity at Work. In addition to the historical exhibits there is a 90 foot diorama flanked by replicas of the Pearl Street and Appleton Stations. The diorama shown in the headpiece swings from the mountains on the left to a city on the right, showing in addition to a high head and low head hydraulic plant and a modern steam plant, the application of electricity

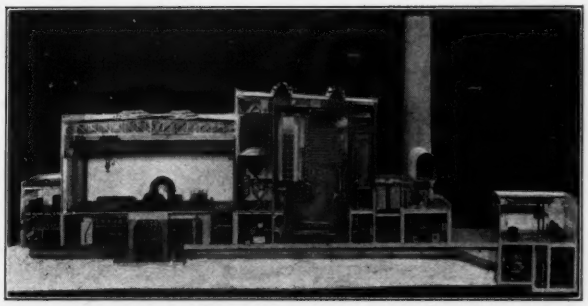


FIG. 3. THE MODERN STEAM STATION OPEN FOR INSPECTION

to all services, rural, industrial, metropolitan and residential power and lighting. The plants and equipment are sectionalized to show the construction of equipment while water and steam actually circulating through the glass tube piping shows how the entire plant works.

The diorama is animated with lights and flowing water, spinning turbines and all the movement of busy life. A recorded voice issuing from a hidden source will point out the features of the diorama and trace the flow of electricity from generation to final use. A sequence of light and darkness on the scene will simulate day and night so that the observer will see windows begin to glow at dusk and shadowy streets become paths of brightness. By seeing as a whole the complete picture of electricity generation, distribution and use, its various components properly related and connected to each other, anyone who gazes on this diorama must take away with him a clearer conception of what constitutes an electric service system.

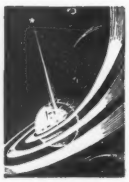
This exhibit was made possible by modest contributions from a large number of electric light and power companies throughout the country. It was prepared under the supervision of a committee of a group of central station engineers and officials, representing The Commonwealth Edison Co., Byllesby Engineering and Management Corporation, The New York Edison Co., The Commonwealth and Southern Corporation, The Union Light, Heat and Power Co., Engineers' Public Service Co., Inc., Electric Bond and Share Co., and The Buffalo, Niagara and Eastern Power Co.

A Century of Progress is laid out in panorama over an area covering a few acres. Who in the time of Faraday would have believed that his simple experiments would lead to such astonishing things as can be seen in the research exhibits of Westinghouse and General Electric? Doors opened by waving a wand, songs sent over a beam of light, a toy piano as big as a hat producing a greater sound volume than the mightiest pipe organ, photo electric tubes sorting black and white balls, an automatic fire department and a host of other things beyond the wildest imagination of Munchausen.

Verily, the day of miracles is not past but even though the past is laid out for your inspection like a book, the future is hid by a veil that the best modern magician cannot pierce. The Century of Progress in electricity is but the introduction to an era still veiled by the curtain of time. An era which will be reached by the paths now being carefully explored inch by inch in the rsearch laboratories. We can see these paths stretching ahead into the mist—we can close our eyes and imagine the wonderland ahead but we must leave to posterity the privilege of following those paths to the end.

POWER PLANT ENGINEERING June 1933

INDUSTRY—The Pulse of the Nation



INDUSTRY as we know it today was made possible by the availability of power—first water and then steam followed by the internal combustion engine, later all three being combined with the more modern means of power transmission—electricity. In the short space, somewhat over a hundred years, man has made more progress in arts and sciences than in the centuries that preceded this short era. In fact, many of our industries have grown up during a single lifetime.

Yet modern man uses stainless steel without thinking, perhaps pondering the while on the mysteries of so called tempered bronze of the ancients; he drives up to a filling station and orders gasoline without a thought as to the method by which it is produced or the way in which it is used; if old fashioned he may even take sulphur and molasses in the spring with no thought except the difficulty of buying molasses in this day and age.

Cooperative Effort the New Watchword

Now it is not conducive to progress to have each man working in his own little groove, paying no attention to others, because the world has progressed in proportion to the free and unfettered interchange of ideas. It is to smooth the ruts and further interchange of ideas that the exposition was organized—a serious contemplation of the future of the world under the sugar coating of an anniversary carnival. Today nearly 40 per cent of the people living in the United States derive their living and support from industries that were not in existence in 1893. Social changes of a profound nature have accompanied this industrial transformation. The interpretation and explanation of these changes provide the medium for new types of exhibits, a new age with a story to tell and a new method for telling it. Successfully presented, it is enlightening and encouraging to those who come and study it, for it will be a preparation for the future as well as a celebration of the past.

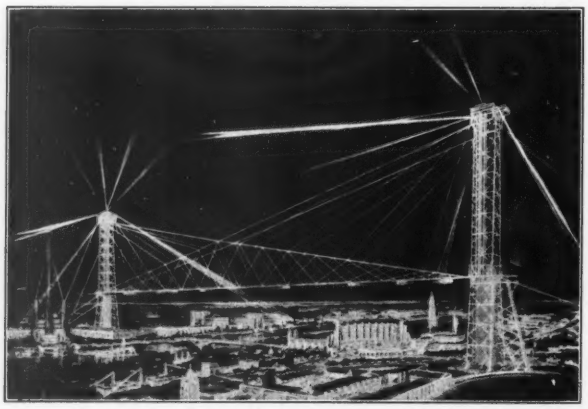


FIG. 1. THE SKYRIDE WITH TWO 620 FT. TOWERS DOMINATES THE FAIR

Education is being fostered under three general groups. The basic social and physical science exhibits prepared and arranged under the direct supervision of the management to give a scientific background; the industrial science groups under representative trade associations such as the American Petroleum Institute, The Paper Foundation, the Central Stations Industry and the Copper & Brass Institute, arranged to show the accomplishments of entire industries; individual company exhibits prepared to show accomplishments of commercial organizations.

Lighting Is Sensational

Actually it is impossible to separate the whole into its component parts because they have been skillfully arranged to show each phase in its true relation to our complex scientific-industrial structure, each part of which is mutually dependent on the others. Thus the Central Station Exhibit, is completed by the adjacent General Electric and Westinghouse exhibits showing the commercial facilities behind the industry as a whole.

Unique and novel lighting effects and luminous fountains, scintillating in mobile color, will stimulate the throngs of visitors and make them realize that the opening of a new era is being celebrated. The general illumination of the grounds will introduce a new note in outdoor lighting and to those accustomed to ordinary lighting standards and lanterns, the warm glow which will be produced by the Mushroom shaped luminares will be particularly attractive. The unusual character of the architecture of the Fair and the vivid colors of the buildings calls for combinations of lighting effects and mobile color treatment such as has never been contemplated on a large scale.

History Not Forgotten

Similarly, the Gulf Refining Co. is cooperating with Westinghouse in a spectacular 25,000 v. transformer display arranged to show the action of arcing horns on the transformer cover and through a glass window the application of oil for insulation and cooling. Flow measurement is one of the important phases of both power and industrial work and the development from the simple manometer to the modern instrument is displayed by the Foxboro Co. while the Builders Iron Foundry will exhibit the old Venturi registering device which measured the water flow of the World's Fair of 1893, alongside of the modern equipment showing

the water consumption of the present fair hour by hour. This water demand by the way is estimated at 20 m.g.d. and will be supplied from Lake Michigan, suitably chlorinated, by a separate pumping station using Yeoman pumps.

The exposition as a whole is a revolutionary departure from conventional architecture and construction. Modernistic in design, the height of the buildings is not apparent, even the 620 ft. Sky Ride towers seen against the background of these immense buildings seems dwarfed. Construction costs are unbelievably low, salvage values high and the details are well worthy of study.

Elevators Shown in Operation

The Sky Ride, with two tall towers and a span of 1850 ft., is hailed as the amusement sensation of the fair, comparable only to the Ferris Wheel of 1893. Cars suspended from the cable way have a capacity of 4800 visitors an hour. Strange as it may seem these structures have real commercial use and are used in Europe to take the place of bridges for long spans where shipping cannot be interfered with. Carrying cables, supported by a special carrying arrangement covered by the Hamilton patents, have a maximum sag of about 20 in. Each tower will have four automatic high speed Otis elevators, two 500 f.p.m. 30 passenger cars to the 200 ft. rocket car level and two 700 f.p.m., 22 passenger cars to the 600 ft. observation platform. Both the elevator hoistway and motor room will be open for inspection.

A Building that Actually Breathes and Expands Three Feet in Circumference

Another marvel of construction is the suspended dome of the Transportation Building. This dome is 125 ft. high and 200 ft. in diameter without a single arch, pillar, beam or other support. The construction difficulties encountered can be appreciated when it is realized that weather changes cause a maximum circumference change of over 6 ft. and a vertical change of 18 in. Located near the south end of the grounds this will be the center of the transportation group. Railroad, automobile, airplane and steamship history will be told and forecast by exhibit and pageant. The famous Royal Scot of Great Britain will be on exhibit and the immense dome will be used by the Standard Oil Co. as a pictorial representation of the use of petroleum products in the field of transportation. The Bureau of Navigation (U.S.) will supply the nautical touch with a full size forecastle of a sailing ship of 50 yr. ago contrasted to that of a modern ship with all navigating instruments and safety appliances. General Motors and Chrysler will show the modern automobile from raw product through the testing ground to the consumer while those interested in aerial transportation will be afforded the the privilege of the air by the Goodyear blimp.

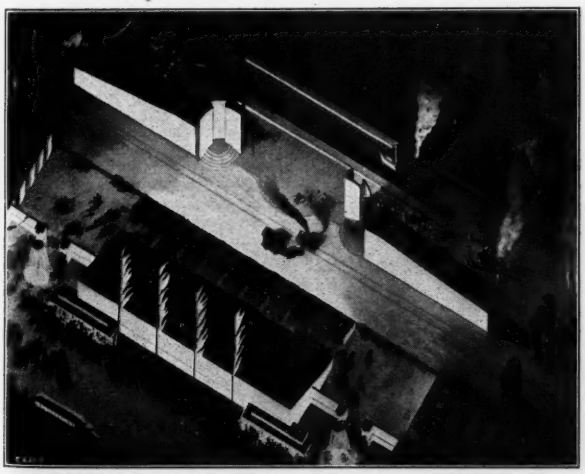


FIG. 2. WINGS OF A CENTURY—A PAGEANT OF 100 YR. PROGRESS OF TRANSPORTATION BY LAND, WATER AND AIR

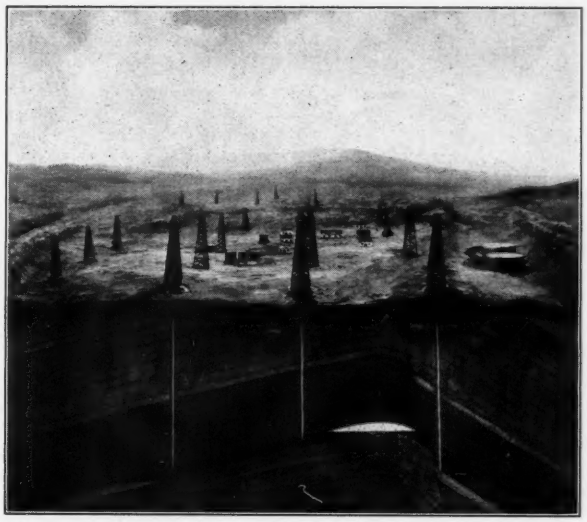


FIG. 3. A WORKING DIORAMA OF AN OIL FIELD SHOWING THE PROGRESSIVE CHANGE FROM GAS TO OIL TO WATER

Available fuel has of course greatly assisted industrial development and as one of our youngest and most important industries, petroleum has a prominent place. The exhibit is most unusual and complete, centered largely on the main floor of the Hall of Science. It will be a presentation of the exploration, drilling, production and transportation of petroleum and natural gas. The object is to explain to the general public the ramifications of the oil and gas industry, its magnitude and the intricate details of operation necessary to locate, produce, and to transport the crude products. Refining processes are in the chemical exhibits.

New Science of Metals Has Revolutionized All Modern Industries

Metallurgy is another phase of science that has been instrumental in making modern equipment possible. Alloys with special corrosion resistant properties, high tensile strengths, light weights and with special electrical properties are research developments. Westinghouse is featuring these products in a special cabinet opened by a beam of light, Crane Co. in valves, Link-Belt in application to special conveying equipment, Timken in roller bearings. Closely allied are the plastics represented by products of the Bakelite Corp. and the special colored and inlaid panels of the Westinghouse exhibit hailed as the modern decorative motif.

Communications give speed to our modern age and are allotted a special building in the Electrical Group where the telephone and radio hold sway. The paper industry is represented in the Graphic Arts Pavilion

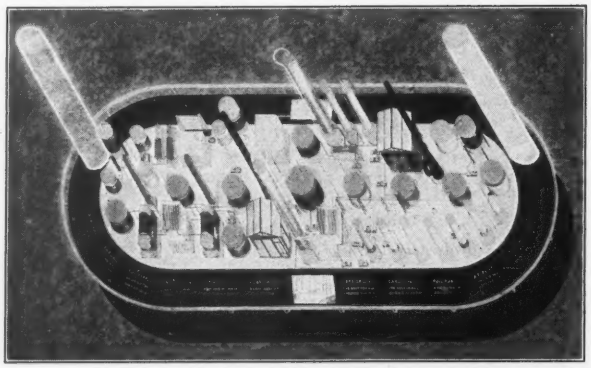


FIG. 4. A MINIATURE OPERATING REFINERY IN THE HALL OF SCIENCE IS 30 FT. LONG AND CONSTRUCTED OF GLASS SO THAT THE PROCESSES CAN BE FOLLOWED BY VISITORS

of the General Exhibits group north of the Hall of Science by 10,000 uses of paper from napkins to cartwheels. Marvels of modern air conditioning will be shown by The Fox Furnace Co., General Electric and Westinghouse by full size operating equipment.

At the entrance of the Electrical Building is a wide doorway the gigantic figure of a man, one hand on a switch, the other on a generator. Here the Copper Highway begins, continuing around a circular balcony to the various sections of the Central Stations Industry Exhibit with a sign "Follow Electricity Down the Copper Highway." From the generator will run a triple line of copper bus bars, standard in every way and precisely the same as those used in generating plants and central stations. The bars will shine against a black background, with concealed lighting effects, with the middle bar lower than the outer two, for emphasis. At intervals along the Copper Highway smaller bus bars will run to the various exhibition booths which will show, in turn, modern lighting effects for the home, the office and all other purposes. On one side of the balcony, which is circular, will be the displays of the Central Station Industry Exhibit; on the other, over a railing, will be seen, twenty feet below, the exhibits of the General Electric Co. and the Westinghouse Electric & Manufacturing Co.

General illumination controlled by the photo-electric cell, or Electric Eye, and black board lighting for the conservation of child eyesight will feature the model school room. With the collaboration of the University of Chicago this exhibit will include a demonstration of the use of talking motion pictures in education. One feature of the hospital display in which the uses of electricity in medicine and surgery will be shown will be a modern operating room.

Industrial aspects of electricity utilization will be an important part of the exhibit. Most people think in only the vaguest sort of terms, of the great strides that have been made in the past few years in industrial technique. They have heard of marvels, but have not actually seen them. Here they will have opportunity to see, for instance, an electric furnace with a magnetic brain that controls temperatures more closely than any manual device might do, machines operated by the infinitesimal response of the "electric eye" to color changes or variations of shape. A few years ago, cast iron was cast iron, a brittle material of very restricted uses. The electric furnace changed that and now cast iron can be used for the strenuous duty of automobile motor crank shafts. Such a furnace will be on exhibit as will be numerous other special applications of electric power, heat and light to specialized industrial processes.

Of considerable importance is the power supply for the exposition. This is supplied entirely by the Commonwealth Edison Co. of Chicago. This company has invested $176,000 in conduits, cables and substation equipment at the exposition grounds. Light and power requirements with the fair grounds will take approximately the same volume of energy as a city of 150,000.

All of these industries and many more too numerous to mention help to make our country and it is quite appropriate that the Government Building, flanked by the States Group, should have the most impressive and perhaps most prominent location across the lagoon from the 12th Street Gate. Department of Commerce Exhibits will be especially interesting and will cover the activities of the Aeronautics Branch, Bureau of Standards, Census Bureau, Foreign and Domestic Commerce, Fisheries, Lighthouses, Coast and Geodetic Surveys and Bureau of Mines, all activities of vital interest to the engineer.

When Industry Closes Her Eye

And last—to the serious minded but of considerable importance to the Forgotten Man in his very human hunt for the Carnival Spirit—is the Midway, "The City of a Million Lights" and sideshows, Hollywood transported complete with the Romance of the Movies, monsters of a prehistoric age, Admiral Byrd's polar ship, the City of New York, Fort Dearborn and the Lincoln group, the Foreign Cities, a myriad of unexplored corners, restaurants and new sights and five acres of The Enchanted Island, the mysteries of which will remain mysteries except through juvenile gossip—adults are forever barred from this parentless Eden.

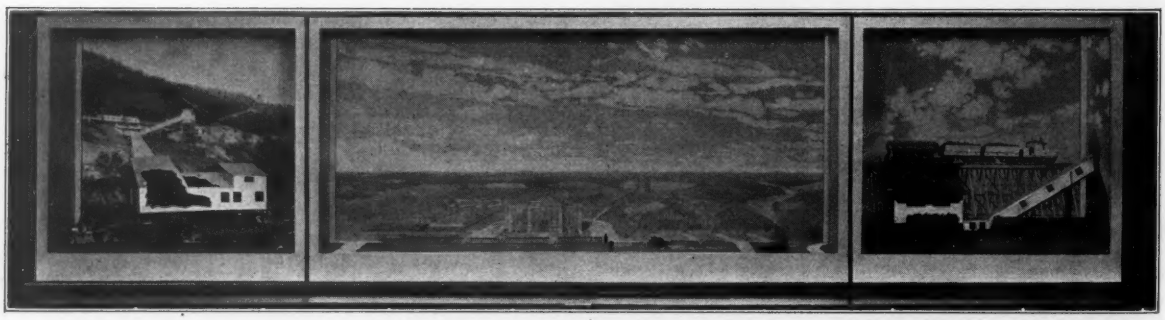


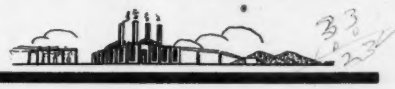
FIG. 5. THE ACCOMPLISHMENT OF LINK-BELT CONVEYING EQUIPMENT TOLD BY COLORFUL DIORAMAS

Twenty Years of MERCURY VAPOR *Power Development*

WITH the opening of two large stations using the mercury-vapor steam cycle recently, interest in this method of power generation has been renewed. We expect soon to present an article dealing with the design and construction of at least one of these new plants.

To furnish a background against which to view these new stations we present here a brief history of the mercury-vapor cycle as it was developed at Schenectady and Hartford during the past 20 yrs. It is to the ceaseless efforts of the pioneers at Hartford that the new plants owe their existence.

Without the work of the pioneers at Hartford, without their vision and confidence in the ultimate success of the mercury vapor process, the new plants at Kearny and Schenectady would not be possible.



WITHIN THE PAST FEW months two 20,000-kw. mercury vapor power plants have been completed and placed in operation, one by the General Electric Co. at Schenectady, N. Y., and the other by the Public Service Electric Co. at Kearny, N. J. The operation and performance of these stations will be regarded with great interest by power plant engineers throughout the world for each of these plants have twice the capacity of the one and only existing mercury plant in commercial service, that is the one at the South Meadow Plant of the Hartford Electric Light Co. at Hartford, Conn.

In view of the great interest exhibited in these two stations and of the confidence felt in the mercury vapor cycle by the power station engineers and officials of the General Electric Co., it is both timely and appropriate that we should review the history of the development of this process. Judging from the remarkable economies effected by the use of this process undoubtedly it is destined to play an important part in the future development of electric generating systems.

It is interesting to know that these two stations go into operation just 20 yr. after W. L. R. Emmet first announced his plan to use mercury in a binary vapor cycle in a paper presented before the Schenectady section of the American Institute of Electrical Engineers. This paper[1] was presented on December 16, 1913. Indeed, the history of the development of the mercury process seems to divide conveniently into two 10-yr. periods—the first extending from 1913 to 1923 which may be regarded as the purely theoretical and experimental stage, during which time no commercial applications were made, and the second, from 1923 to 1933, which may be termed the "Hartford period" or the period of its commercial development. The first commercial unit was placed in operation at the Dutch Point Station of the Hartford Electric Light Co. in June 1923, ten years after Mr. Emmet's first paper. Now, in June, 1933, the process is entering upon the third period of its development with the opening of the two 20,000-kw. stations at Schenectady and at Kearny.

[1] Transactions A I E E, Vol. XXXVI, pp. 2133-2149.

The road from Mr. Emmet's first paper in 1916 to the new plants at Schenectady and Kearny has not been an easy one. Though the theoretical concept of the process was clear from the beginning the development of a practical system presented tremendous difficulties, which only extreme patience and a gradual accumulation of knowledge and technique overcame in the end. Great credit is due to both the General Electric Co. and the Hartford Electric Light Co. for their vision and in seeing the work through as well as for their encouragement of those men whose perseverance and technical skill made a successful solution possible.

When Mr. Emmet presented his first paper, he had developed the idea of the mercury cycle in full detail and all efforts since then have been directed toward working out the details and overcoming the difficulties of operating equipment at high temperatures for long periods. The idea of using mercury was to increase the efficiency of the process of converting heat energy into mechanical energy. Thermodynamically his idea was perfectly sound.

The method first proposed by Mr. Emmet in utilizing mercury is the same as in commercial use today, that is, mercury is vaporized in a boiler heated by a furnace of ordinary type, from which it passes at comparatively low pressure to a turbine driving a generator. From this turbine, it passes to a condensing boiler where it is condensed on the outer surface of tubes which contain water and this water is vaporized by the heat delivered. The steam so produced is used to drive other turbines.

The advantages of mercury as a thermodynamic fluid are many. Its boiling points at desired pressures are convenient. Its high specific gravity makes possible the use of gravity feed. It is completely neutral at the temperatures used, to air, water, iron and it carries nothing in solution which can adhere to or affect heating surfaces.

One question which arose quite early in the development of the mercury boiler was the poisonous character of mercury. This, however, proved to be less dangerous than at first thought. The first installation was made

without any safeguards whatsoever to keep the men from contact with mercury or mercury vapor, due to the fact that at that time the welding process was undeveloped and that the shaft packing of the mercury turbine was under pressure and as a consequence there was considerable leakage. There were three cases of minor poisoning but none of them caused more than two or three days inconvenience. This led to a study of the situation which resulted in the design of a new turbo-generator which made it impossible for an operator to come in contact with mercury vapor. At present, the mercury process is far safer for the operator than a steam system.

Once, during the operation of the second boiler at Dutch Point, one of the headers split open, cracking at a welded joint over a considerable distance and pulling out a number of stay bolts. This happened at about 40 or 50 lb. pressure, and if it had been a water boiler, there would have been a tremendous explosion with great injury to property as well as to the attendants. Due to the characteristics of the mercury vapor, there was no explosive violence and the men in front of the boiler did not know that a rupture had taken place. They merely noted a dropping of the mercury level.

Since the first three cases of mercurial poisoning in 1923-4, there has never been a case of either acute or

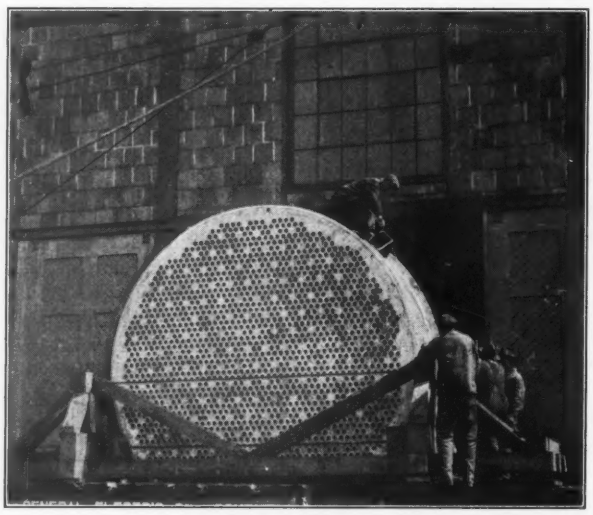


FIG. 1. THE FIRST "CHEESE BOX" BOILER USED AT HARTFORD

This was a fire tube boiler, of rather complicated construction in which six tubes were placed hexagonally around a "down" tube having very thick walls. It had fundamental defects and was abandoned in 1925.

chronic poisoning in connection with all the work that has been done on the system. The construction work of rebuilding at the South Meadow boiler was carried on with no more precaution than would be necessary in any work where gases are present.

At the time of the poison cases there was no information whatsoever on mercurial poisoning. There were an enormous number of compensation cases and there was no literature on the subject and no precautions taken where mercury was used in industry to protect the operators.

Never before had mercury even been boiled in process work. For this reason, it was necessary to start from the ground up to take care of the possibility of mercury poisoning and study the effects on the operators by continuous examinations. Today "Hartford" considers the operators in the mercury plant absolutely safe from any possibility of injury through the use of the mercury vapor process.

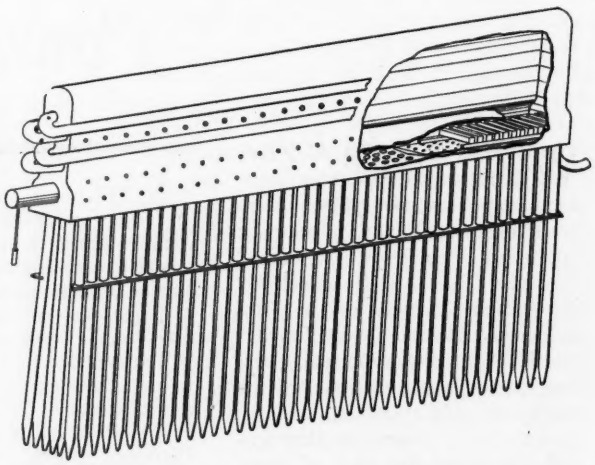


FIG. 2. THE SECOND TYPE OF BOILER INSTALLED AT HARTFORD

This was known as the unit tube boiler and is the forerunner of the present porcupine boiler used at the new plants at Schenectady and Kearney.

It is unnecessary here to describe in detail all of Mr. Emmet's early experiments. As he expresses it himself, he had to "dig up knowledge" not only on mercury vapor characteristics but on the design of a suitable boiler and turbine. The first experiments were made with tubes containing solid cores with a small clearance between the core and tube and a central hole in the core for circulation of the liquid. These experiments showed that to absorb a large amount of heat, it was necessary to provide a very free circulation of the liquid. The first boiler was a small affair consisting of flattened tubes bent into an arc and welded into two headers together with a return pipe. With various modifications this was the type of boiler used in Schenectady until the Hartford equipment was built in 1923. This equipment was ultimately run with loads as high as 1000 kw. with results that showed that the economies claimed for the process could be realized.

Up to this time all work had been done at Schenectady. Shortly before 1923, however, the Hartford Electric Light Co. made a voluntary offer to make a large installation and so arrangements were made to install equipment in their Dutch Point Station. The Hartford Electric Light Co. deserves a great deal of credit for this step and for the years of development work later on.

This first installation at Dutch Point was designed to operate with 35 lb. gage pressure on the mercury boiler, to deliver 1800 kw. from the mercury turbine and to make steam at 200 lb. pressure with 100 deg. superheat. The boiler was of a type which later on became known as the "cheese box" boiler, since it consisted of a flattened cylinder, containing fire tubes. Fundamental difficulties were experienced with this boiler, due to the

opening up of welded joints and after operating it, on and off, over a period of about two years, in 1925 a new installation was made, incorporating an entirely new type of boiler.

Considerable had been learned in the operation of this installation. There were many leaks and welding processes were developed to overcome them, indeed, this

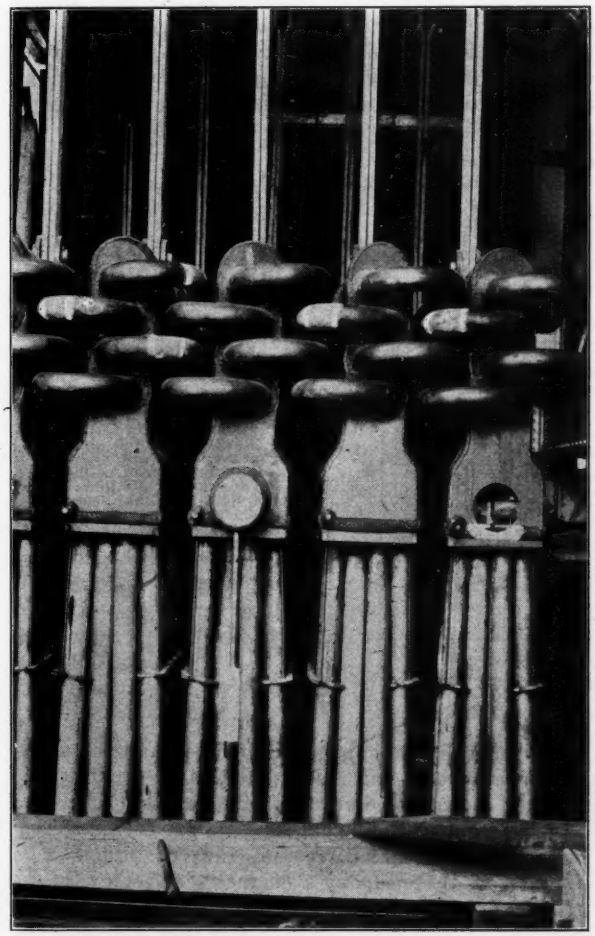


FIG. 3. A VIEW OF THE UNIT TUBE BOILER AS ASSEMBLED

was the first installation where welding was depended upon for mechanical strength. Turbine construction also was improved. The first set of blades used were made of high speed tool steel. This proved entirely unsuitable, as it was too brittle. So new blades were installed, of the same type of metal as was in use in steam turbines at that time, about a 3 per cent nickel steel.

The new boiler was to operate at 70 lb. gage pressure instead of 35 and was quite different from the first. It was called the "unit tube boiler." In this boiler each tube was complete in itself, having both up passes for vapor release and down passes for liquid return—a complete vapor generator. The boiler was constructed in sections, each section consisting of 60 tubes grouped into a unit header thus making it possible to make up a boiler of any desired size by tying sections together. The type of tube used is shown in Fig. 4. These tubes were 3 in. in diameter by 5 ft. 6 in. long and calorized throughout their entire length. One end was tapered and closed at the tip by welding while the other end was rolled and welded into a tube sheet. On the near side of the tapered portion were small centering fins to give clearance between the walls of the core and tubes. The core was a thin walled tube on the outside of which were ribs to center it and provide passage for mercury and vapor. The center of this core was a small steel pipe about ½ in. inside diameter, welded to the tube at either end, the space between the near pipe and the outer tube being filled with air. In order to relieve the pressure in this air space and prevent possible trouble in case a core leaked and filled with mercury, a small vent pipe was welded into the upper end and allowed to extend above the liquid level. These dead ended tubes extended down into the furnace. Liquid mercury passed through the down tube inside the core into the annular space between the core and the outer tube where it was vaporized, the vapor passing upward into the header. This was the fundamental principle of the new boiler.

The turbine was very simple, it being merely a three stage impulse wheel, the last wheel being slightly less than 5 ft. in diameter.

This new plant was completed early in July and on July 16, 1925, a small fire was lighted and the boiler slowly warmed up until a pressure of 15 lb. gage was

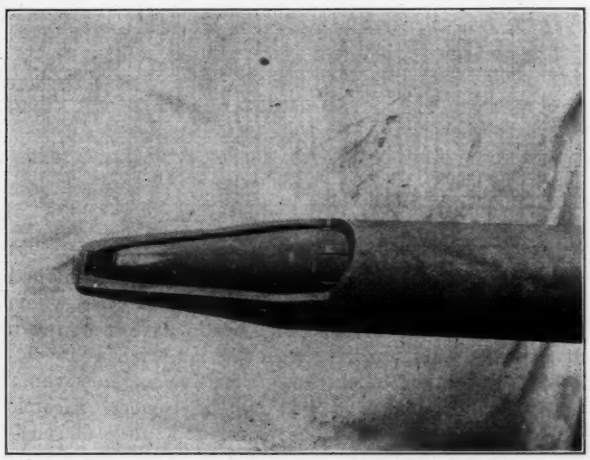


FIG. 4. LOWER END OF TUBE WITH CORE IN PLACE

reached. The total time the fire was lighted was approximately 9 hr. Everything seemed to be all right except that the mercury level had fallen an inch. More mercury was sent for but during the succeeding days the level continued to fall until around July 25th a bad leak was found in a weld on one of the boiler sections. It afterward developed that this weld was cracked in the shop and the trouble had not been detected on tests due to its being heavily painted. In order to repair the weld the section was taken out and the header completely cut off to inspect the tube cores. As had been surmised these tubes had acted as condensers and had begun to fill up gradually. It was later discovered that the straight down tube used had in a great many cases broken loose in the welds, allowing mercury to leak in directly. This meant that the boiler had to be practically rebuilt. The boiler sections were taken to South Meadow Station and the work done there.

The preliminary experience, together with information obtained from experiments by the General Electric Co., resulted in a modified design being adopted. Curved down tube slightly flexible being substituted for the straight ones in the original design. This work naturally occupied a considerable amount of time.

During the rebuilding of the boiler elaborate precautions were taken to prevent mercury poisoning. A large pool was built and all operations involving the spilling of mercury were carried on with the boiler section standing in this pool. Any loose mercury was thus under water. The question of mercury poisoning had come up during the operation of the first equipment at Dutch Point Station and while no serious cases of poisoning had taken place there were a number of minor cases which clearly indicated that great care would have to be taken at all times when working with this material.

For use during operation a sensitive mercury vapor detector had been developed by the General Electric Co. This detector was in the form of a piece of sensitized paper coated with a mixture of selenium sulphite and sulphate which turned brown or black in the presence of mercury vapor.

It was November 30th before the fires were lighted again and the boiler warmed up slowly until the pressure reached 21 lb. Several minor troubles were encountered which were attended to and on December 3rd the turbine ran without load for 2 hr. The next day the load was put on the generator and gradually increased until a maximum of 1300 kw. was reached. At this load the boiler pressure was 50 lb. gage and steam was being generated at the rate of 23,000 lb. per hr. The calculations indicated the turbines to be 10 per cent more efficient than the old one reaching a maximum of nearly 70 per cent. At the higher rating the mercury level dropped more than could be justified and over 1000 lb. of mercury was added to the system without changing the level. When the load was reduced, however, the level came back so it was decided that the boiler was priming. After this run inspection of the boiler showed 10 tubes with small leaks and the welds on many of the tube ends badly burned.

This second plant at Dutch Point Station was operated intermittently from July 16, 1925, until the end of the year 1926. Many minor and some serious difficulties were encountered but despite all discouraging experiences knowledge of mercury vapor plant operation steadily accumulated. At no time did the manufacturers or the operators lose faith in the fundamental principles of the idea or in the belief that a successful system of this type could be designed and so early in the year 1927 the directors of the company decided to recommend to the stockholders that the planned extension to the South Meadow Plant should be obtained by the installation of a new mercury unit. At the annual stockholders meeting this plan was approved and the necessary funds voted for the installation of a 10,000-kw. mercury turbine generator with the mercury boiler and heater and steam and auxiliary equipment for a complete unit. Stone and Webster, Inc., of Boston, were retained as the company's engineers and they as the engineers, working in collaboration with the General Electric Co. engineers, immediately went to work on plans for the unit so that by June 1, 1927, equipment was on the property and work started on the foundations for the building.

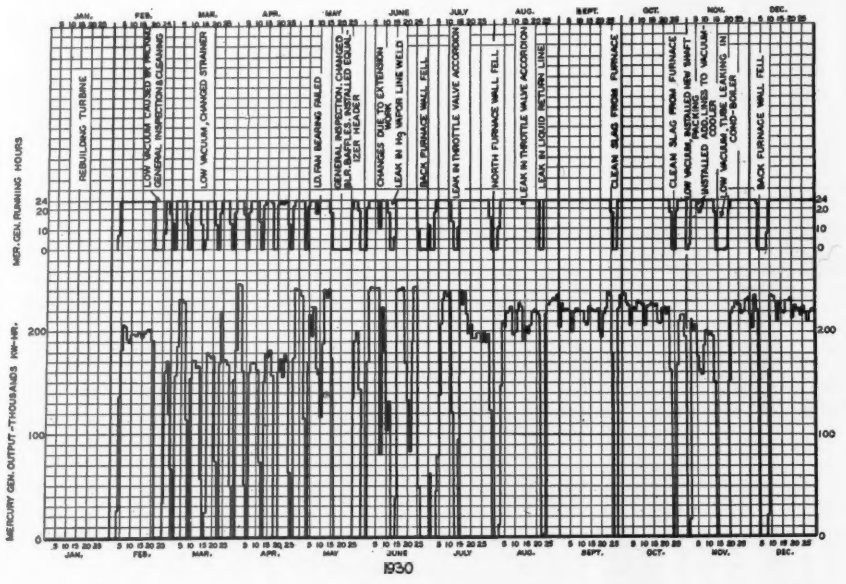


FIG. 5. OPERATING RECORD AT SOUTH MEADOW STATION FOR 1930

This chart gives an idea of the performance of the installation after rebuilding the turbine in 1929. As may be noted, there were numerous shutdowns, but most of these were due to minor difficulties, easily overcome. Modification in certain details of the equipment improved the performance toward the end of the year.

It is well to bear in mind when considering this history and knowing the very considerable part of the total period that the unit was not available for service that even though this unit was considered at the time of its installation to be a commercial installation, there was still a vast amount of research and development work to be done before it would be in a class with the plant designed along the lines of standard steam practice. Because of this, though work on the building had proceeded rapidly, it was not until September 26, 1928, that a small fire was started under the new boiler and the equipment gradually warmed up. Minor difficulties were encountered and these were remedied before another attempt to operate the unit was made.

On October 4th the necessary changes had been made and the boiler pressure gradually built up to 87 lb. gage to permit setting of the mercury vapor safety valves. The turbine was started for the first time and

brought up to a speed of 540 r.p.m. for a trial run. On this same day the turbo-generator was brought up to full speed and phased in on the line for the first time. On October 22nd the load on the machine was gradually increased until it had reached 10,500 kw. output from the generator. Operation at this load was very satisfactory. This run was followed by a thorough inspection and on November 2nd the turbine was again started and operated continuously with loads from 1500 to 10,000 kw. on the mercury generator until November 16th when the failure of a boiler tube made it necessary to shut down. The operation during this entire period was very satisfactory and demonstrated a considerable fuel saving obtainable through operating the existing steam turbines in conjunction with the mercury system.

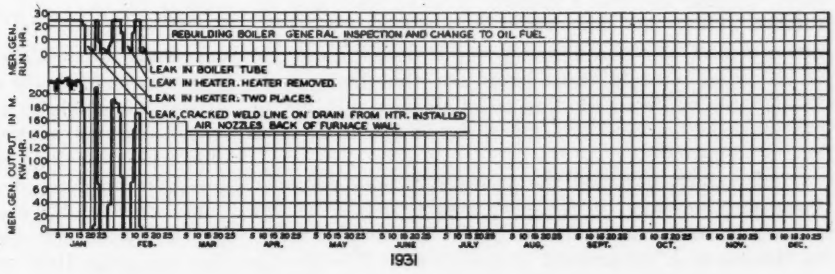

REBUILDING BOILER GENERAL INSPECTION AND CHANGE TO OIL FUEL
LEAK IN BOILER TUBE
LEAK IN HEATER. HEATER REMOVED.
LEAK IN HEATER. TWO PLACES.
LEAK, CRACKED WELD LINE ON DRAIN FROM HTR. INSTALLED AIR NOZZLES BACK OF FURNACE WALL
MER. GEN. RUN HR.
MER. GEN. OUTPUT IN M. KW-HR.
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1931

FIG. 6. OPERATING RECORD AT SOUTH MEADOW STATION FOR 1931

The boiler was taken out of service on Feb. 31, 1931, on account of a tube failure. This resulted in the development of new type tubes and the rest of the year was spent in rebuilding the boiler.

The tube trouble referred to was caused by obstructed circulation between the boiler tube and the core and investigation indicated that a different design of core was necessary so it was decided to rebuild the boiler and work of remodeling the old cores was begun in the first part of December.

The work of rebuilding and redesigning this boiler occupied the entire first part of the year 1929 so that the mercury plant was shut down during this entire period. On July 21, 1929, work on the boiler had been completed and a burner was lighted and the pressure on the boiler gradually raised. The turbine was started at 5:30 a.m. on July 22nd. Average load of 4000 kw. on the generator was maintained until August 1st during which time the boiler was watched for any sign of overheating or leakage. After shutting down on August 1st a thorough inspection was made of all parts of the equipment, the results of which were encouraging since the boiler tubes had neither distorted or grown appreciably.

The unit was again operated from August 13th to September 1st and from September 4th to September 15th with loads varying between 5500 and 7700 kw. The boiler and turbine operated very well at 7700 kw. until 12:30 p.m. on September 15th when the turbo-generator began to vibrate badly. By 1 p.m. the trouble had been definitely located. It was coming from the turbine and the unit was vibrating so badly at this time that it was taken off the line and shut down. The turbine was opened immediately and it was found that the second stage diaphram was distorted, its holding bolts had broken and the diaphram had been rubbing against the first stage wheel. Upon further dismantling it was found that the second and third stages had also been damaged. All wheels and diaphrams were therefore removed and shipped back to Schenectady where the diaphrams were rebuilt under new design with high temperature material.

The fires were again lighted on February 4, 1930, and from that time until approximately a year later the equipment was in operation more or less continuously.

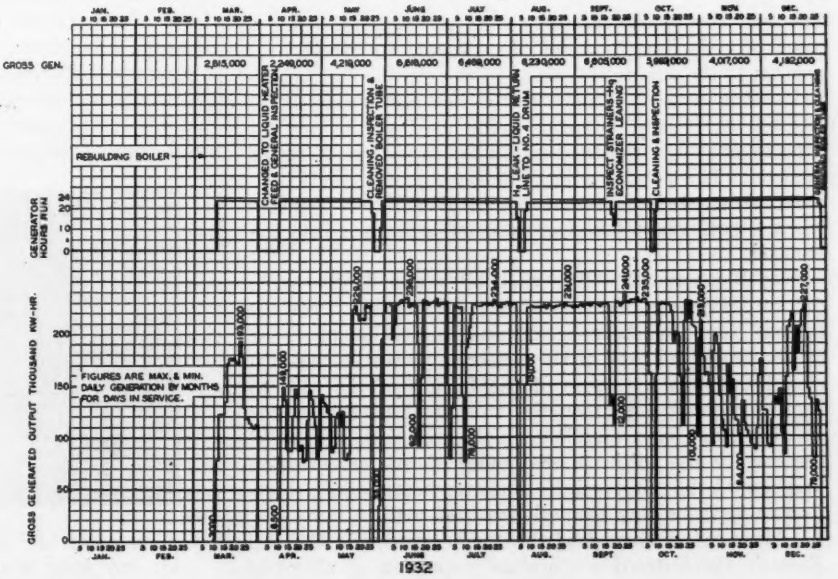


FIG. 7. OPERATING RECORD AT SOUTH MEADOW STATION FOR 1932

Showing performance of the plant after rebuilding the boiler in 1931. It is only necessary to compare this chart with the one on page 266 for the year 1930 to realize the progress than has been made. The beginning of the year 1931 was marked by almost weekly shutdowns. Here we see one period of continuous operation for almost five months, with only one short shutdown for cleaning and inspection.

An idea of the performance during that time may be had from the chart showing the operation for that year. There were numerous minor difficulties but most of these were easily overcome and a number of minor modifications were made in certain details of the equipment. During the year a number of small leaks had developed and in one case, which occurred on June 12th, it was found that the mercury vapor detector did not at all times indicate small leaks and that there could be mercury vapor in the flue gases which would not be indicated on the tape by samples drawn from the stack by the detector.

This failure to detect the presence of mercury when there was mercury in the gases was found to be due mainly to stratification of the gases. It was also found by the research department of the General Electric Co. that some of the mercury vapor was being changed to the oxide which would not indicate on the detector. This discovery resulted in the development of an oxide reducing attachment for the detector, thus increasing the sensitivity of the instrument to a high degree.

TABLE I. SUMMARY OF OPERATION AT THE SOUTH MEADOW STATION 1928-1932

Operating Data by Years					
YEAR OF ****	1928	1929	1930	1931	1932
Lbs. Oil Burned	------	------	-------	------	62064784
Lbs. Coal Burned	4836215	9218090	86806670	9941660	-------
Lbs. Steam Gen.	370050000	78115000	713388000	76430000	659813000
KWH - Eg. Generator	2917750	5612000	52460000	5378000	49407000
KWH - Equiv. from Steam	2961470	6417550	70981260	7643000	62396260
KWH - Station Service	160750	353070	2403440	321240	1579810
KWH - Net Total Output	5718470	11676480	121037820	12699760	110223450
Lbs. Fuel per KWH Net	0.8457	0.7895	0.7172	0.7828	0.5630
BTU per KWH Net		11,263	10,340	11,340	10,562
Generator Service Hours	489.25	993.17	6157.0	650.75	6515.5

NOTE:- During the year 1932 the condenser boilers were generating steam at 400# gs. and Bunker "C" fuel oil was being burned under the boiler.

About this same time an application was made of the photoelectric cell so that an alarm would be given with the slightest darkening of the sensitized tape of the mercury detector. Since that time, however, a new detector has been developed, making use of the principle that a beam of polarized light will be affected in direct proportion to the amount of vapor in the gas through which it is being passed. This detector has not replaced the original equipment but it is being used at the present time to make a periodic check on the tape type of vapor detector. The polarized light detector is extremely sensitive, so much in fact that it will immediately register when a half grain tablet of calomel is thrown into the furnace.

On February 31, 1931, the boiler was finally taken out of service on account of a tube failure. Previous to that there had been a continual indication of vapor on the sensitized tape of the detector. Investigation disclosed the primary cause of the failure of the tube to be the rubbing action on the tube wall of one of the small button-like projections on the core which centered the core in the tube. A chattering of this core section had caused the quarter inch diameter button-like projection to wear its way through the tube wall.

After the discovery of these conditions, the General Electric Co. ordered a complete inspection of all parts of the unit and immediately started development work and tests with a view of obtaining better designed tubes. It was felt that even though the existing boiler was entirely re-tubed the existing design was such as to make it possible for this difficulty to recur at any time. In the new design finally agreed upon, and which was the most suitable, the tube has been so modified as to eliminate the filler piece and do away with all loose fits.

The rebuilding of the boiler occupied the entire remaining part of 1931 and the first few months of 1932 so that it was not until March 8th that the plant was operated again.

From March 11th to March 24th the load was gradually built up to 10,000 kw. and from that time on until January 1, 1933, the equipment has been in almost continual operation as can be seen by the accompanying chart. Minor troubles made it necessary to shut the unit down occasionally and sometimes this was done for inspection purposes, but in the main the unit operated more successfully than it had at any time since work on this system was started. The chart showing operation for the year 1932 will show several runs of approximately two months and one from August 7th until December 27th, a period of approximately 5 mo. with only a two day shut down during the first part of October for cleaning and inspection.

This constitutes the history of the mercury turbine development up to January, 1933. As is quite evident and as was pointed out at the beginning of this article, the road which marked the course of this development has not been an easy one. Had it been entrusted to organizations with less vision and confidence in the value of research, it never would have reached the stage of progress it has. Perhaps entire success has not been attained even today but one has merely to compare the last year's performance chart with those of earlier years to see that marvelous progress has been made. Hartford has done its work well. Without Hartford, there would be no 20,000-kw. Schenectady and Kearny Plants today.

Forcing Lamps to Die

OF THE MANY RIGID tests Mazda incandescent lamps must pass before sanctioned for use, that in which they are forced to die is perhaps the most severe. In the factories of the Westinghouse Lamp Company at Bloomfield and Trenton, New Jersey, many unusual tests are constantly in progress to insure that all lamps toe the mark of quality for which they are designed and guaranteed. A check on these requirements is the purpose of the "life" test which forces them to die.

LAMPS UNDERGOING LIFE TESTS

All day long lamps are continually removed from the production line and "burned by the neck till dead" in this test. If designed, for say 110 v., the lamps are burned at 165 v. or 50 per cent overvoltage. Then if they are up to standard in construction, the lamps will burn out in approximately 5 hr. or about 1/200 of their guaranteed life of 1000 hr.

Readers' Conference

Surplus Power a Financial Problem

PRACTICALLY ALL of those who have had something to say on the subject of surplus power have couched it in terms of the most hopeful view and if their arguments were as convincing as they are fascinating most of us would have turned "bulls" in the surplus power market. Not one solitary man has attempted to analyze the problem with a critical eye.

All of the writing and discussion has been thermodynamic. As everybody knows, by far the greater loss in the production of power is in the condenser. But in an industrial process where the exhaust steam can be utilized this loss is entirely eliminated. Putting two and two together the natural conclusion would be that a defensive-offensive alliance between the generating station and industrial plant is the thing. This, however, is only one side of it. When we introduce in the picture the god of finance, the scheme becomes quite unworkable.

Instead of talking B.t.u. which by itself is mere shooting in the air, we will best weigh the pros and cons by taking into consideration both the B.T.U. and the I.O.U. And this can be done best by a study of a hypothetical industrial plant.

We will consider an industrial plant whose heat balance equilibrium can be reached by the installation of a 1000 kw. additional generating capacity. Let us remember that the only industrial concern that will be in a position to market surplus power is that whose exhaust steam requirements are greater than the exhaust steam available from its power requirements. In the case we are considering this difference is to the tune of 1000 kw.

The survival or downfall of surplus power depends on the correlation of these two important questions:

1. What is the price that the public utility will pay for surplus power?

2. What is the cost at which surplus power can be produced?

It is axiomatic that the former of these must be greater than the latter or there could be no transaction.

A little reflection will convince anybody that the price which the public utility will pay for surplus power cannot be greater than its fuel cost. Surplus power will be, in by far the greater majority of cases random power. No doubt there will be exceptions but we are now considering the field as a whole. What few exceptions there will be will not be of sufficient importance to attract the attention of power plant engineers. All of the items of expense except the fuel cost such as fixed charges, labor, supplies and maintenance will not be affected. So that the market price of surplus power will be the fuel cost of the generating station purchasing it.

We have already said that the only industrial concerns who will be in a position to market surplus power will be those whose exhaust steam requirements are greater than the exhaust steam available from the power requirements. Such concerns will already have the boiler capacity but they must go to the expense of installing the generating capacity. At $50 per kw. the total cost of the 1000 kw. generating capacity will be $50,000. The annual fixed charges will amount to $7500 and the additional fuel cost $2500. For the purpose of simplicity as well as to keep on the conservative side we will assume that there will be no other items of expense.

If the industrial concern receives $10,000 per year for its surplus power it will just break even. Of course such a proposition in the business world is moonshine. There must be a profit before any business organization will consider the expenditure of any money. For the case under consideration an annual profit of $5000 is a conservative estimate. Surplus power will have to be sold as any other business deal. The public utility concerns will not push it nor will the industrial concern on its own initiative start generating power as a by-product. The manufacturers of the equipment will be the one to do the pioneering. Their salesman will have to go out and with pencil, paper and the slide rule convince the interested party that with the expenditure of so much money so much profit will be realized. And if the promised profits are less than 10 per cent of the capital investment there will be no signature on the dotted line.

It follows that the surplus power of our hypothetical plant must sell for $15,000 per year. With a load factor of 35 per cent, which is high rather than low when we remember that most industrial concerns operate only 12 hr. per day and are shut down on Sundays and holidays, a 1000-kw. machine can generate 3,000,000 kw-hr. Dividing $15,000 by 3,000,000 we get the unit price at which the power must be sold. This is 0.5 cents per kw-hr.

The question is are there many localities where generating stations are not producing power at a fuel cost considerably less than 0.5 cents per kw-hr. Those familiar with the power industry know that the answer is an emphatic NO. In fact there are central generating stations whose fuel cost is a mere fraction of 0.5 cent, and the number of such stations is increasing. Plants with a fuel cost of 0.5 and 0.4 cent are being shut down and modern stations going up producing power with a fuel cost of 0.2 and 0.15 cent.

Suppose that in some isolated instance an industrial concern is offered a price of 0.5 cent. What assurance would it have that the next year or the year following some generating station will not be built nearby producing power at a fuel cost of a fraction of 0.5 cent and render the purchase of the surplus power impractical? What public utility concern will sign a long year contract to purchase surplus power in the face of the present tendency of building more and more efficient generating stations? Knowing this, can there be many industrial companies that will undertake to spend money with so frail a prospect?

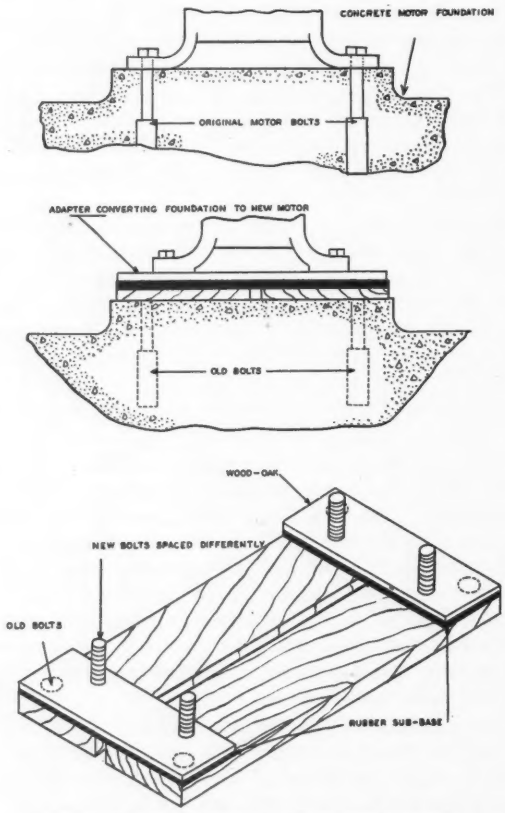
Let us cut our estimate of the cost of generating surplus power from 0.5 to 0.25 and even then we will not find much of a market for it. For we must remem-

ber that the public utility is also entitled to some profit in the transaction. Why should it entangle itself by such an alliance with industrial concerns?

Chicago, Ill. N. T. Pef.

Changing Foundation to Accommodate New Motor

The power motor for the machines of a small shop, recently required renewal. The new motor selected would not secure to the foundation bolts in the shop due to a difference in the base. Inasmuch as the old bolts were firmly imbedded in seasoned concrete, the adapter shown in the attached drawing was devised to meet the need. This adapter was made from oak and resilient rubber pads added, which combined with the elasticity of the oak platform provided against pounding of the motor.



DETAILS OF NEW MOTOR FOUNDATION

Wearing out of the removed motor was attributed to the rigidity of the bolting, causing the bearings to go and the armature to contact with the fields, also causing brush troubles. The new mounting proved satisfactory in every detail, the motor being allowed sufficient freedom to work silently and without destructive pounding.

Washington, D. C. G. A. Luers.

Curing Air Line Troubles

We had several machines which were operated by compressed air devices such as air clutches, air clamps, vibrators and air cylinders and we surely had plenty of trouble. The devices filled up with water, scale and rust mud which wore the leather, plugged the valve mechanism and ruined the screens for they would fill up with dirt and scale and then be ripped open by the air pressure which was 100 lb. to the square inch.

This annoyance was endured for several years under the delusion that it always went with compressed air equipment anyway. Then one day the plant engineer, the master mechanic and the millwright foreman got together with the result that the 2-in. overhead feed line on each side of the shop and all piping to the various machines was taken down. Then two new 3-in. all welded feed lines were erected in their place. The numerous outlets to the various machines were made by welding a 1¼-in. nipple into the top side of the pipe before erection and this was then reduced by a 1¼ to ½-in. common ell. Next the ½-in. lines were piped down to air devices on the machines. Before the connections were made, however, all these were well blown out and rapped at the same time to clean out all dirt and scale.

This arrangement, on account of the very liberal pipe size slowed down the air velocity so that any iron rust or scale that was floating in the air stream together with moisture and spray was now permitted to fall to the bottom part of the pipe. Since the air was taken from the top and through a large outlet, so no violent sucking effect was made, it was clean and dry and the troubles with compressed air devices ceased over night for the water, scale and rust now stayed in the feeder main. The feeder mains were also pitched sufficiently so the water drained in the direction of the air flow, which of course aided it, and at the dead end we welded a smooth ell and then piped the water, slime and scale into a trap which discharged into the storm drain.

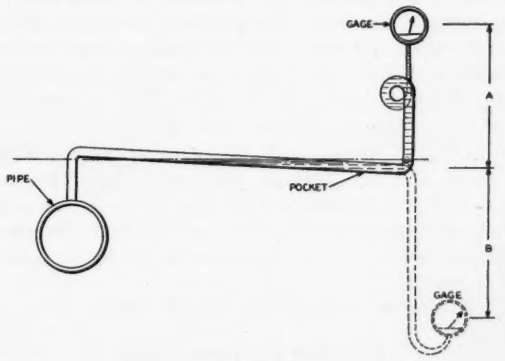
This entire arrangement was most satisfactory and we found that practically all the junk would collect in the two traps which we cleaned out twice a year. The cost of the new line was soon cancelled by the saving in millwright and operator time which had been taken in keeping the air devices in running order and production was improved.

Moline, Ill. Geo. P. Pearce.

Installation of Gages

Water heads due to improperly drained piping are a common source of error in steam and air gages, especially when the pressures being measured are low, as a water leg collects and the static head built up by the water may be greater than the pressure itself. With such a water leg, when the gage is above the point of connection the gage will read low and when below the point of connection the gage will read high. This is explained by the accompanying sketch. The head of water A counteracts some of the pressure while the head B adds to the pressure. Corrections can be made, of course, but these are bothersome and not always reliable because the water may not always be there as expected or the whole length of pipe may not be full.

Connecting pipe should also be rigid and well supported as loose pipes may cause some baffling problems as shown by the following example related to me some time ago. The gage was installed with a rather long line to get it to the board from the engine receiver. During certain periods it was found impossible to maintain



the receiver pressure desired. After considerable investigation it was found that the night engineer sometimes, on warm evenings, hung his jumper on the ¼-in. line above where he kept his lunch warm. This bent the pipe and caused a pocket to form. Condensation soon filled the line and caused the gage to read low and give a false reading. If the line had been properly supported this would not have happened.

Brooklyn, N. Y. P. F. ROGERS.

Steam Piping for Oil Fuel Tanks

REFERRING to the article, Oil Fuel Firing and Combustion Equipment, appearing in April number of Power Plant Engineering, E. G. Peterson writes on page 169, the following: "All pipe connections inside of tanks should be welded except where threaded into couplings extending through the shell of the tank. This applies to internal heating coils and their connections, as leakage of steam into a body of oil may result in boiling over the tank."

From the above extract of Mr. Peterson's article, one is led to believe that welding is the solution to leaky oil tank heating coil problems and the screw joint is the cause of them. Such a statement should be taken with the traditional grain of salt.

Welding has acquired great momentum in the field of piping but it is not safe to say that it may be used to the best advantage to the exclusion of other methods. The importance of welding the inside piping of an oil tank and the principal reason for its use at all, is due to the fact that in certain instances its employment yields the greatest return per dollar invested in the oil tank piping and in the equipment of which this piping is a part.

This writer is not of the opinion that all pipe connections or the major portion of them should be welded, but each installation should be studied to determine the best method.

It may be of interest to those contemplating having this work done to know that troubles from leaky joints may often be traced to improperly selected pipe material. The selection of a pipe material for a given service seldom takes into consideration the threading and welding characteristics of the metal selected and often the crux of the whole problem lies here. A good threading material is not a good welding material in all cases and vice versa.

Some of the working characteristics encountered in the threading of steel pipe with standard equipment is that open hearth steel is most difficult to thread properly, the sharp crests of a thread with this metal are often considerably rounded and irregular, consequently this leaves a crevice at the top and bottom of the thread. Bessemer steel will thread more readily and wrought iron pipe will thread with no difficulty at all, the sharp crests of a thread cut on this metal will roll into a less perfect thread of a commercial fitting and help considerably in making a tight joint.

Some of the welding characteristics encountered are that open hearth steel is the better for welding, because it is softer and tougher, more ductile and contains less sulphur and phosphorus. While the carbon content in Bessemer is lower than in open hearth, Bessemer steel has a higher tensile strength, but its ductility is lower than open hearth, which makes it less desirable as a base metal for welding coils inside of an oil tank. Most all the steel used for pipe has a high melting point and is difficult to weld, especially in a cylindrical oil tank and the coil be a return bend type.

Joints of a steam coil in an oil tank are often subject to considerable water hammer shock, the metal used here should be low in carbon in order that the welder can provide a joint that will not be brittle and will stand considerable shock.

Large O.D. pipe is generally furnished in open hearth steel; while sizes up to 12 in. is furnished in Bessemer, but selecting pipe as so many lengths of pipe is sure to cause trouble, if the joint is welded or screwed. Piping to be welded and immersed in oil should be low in sulphur content as sulphur causes the welds to be porous.

If a porous weld shows up after the oil is in the tank an element of danger is introduced going into the tank with a lighted torch, no matter how dry the tank is pumped and the coil is cleaned.

Brooklyn, N. Y. WILLIAM ANDERSON

Hi-Pressure Steam Boiler at an Austrian Colliery

AT THE RENATE patent fuel works at Niederlausitz, Austria, of the Ilse Mining Co., a somewhat noteworthy high-pressure steam-operated electric plant has recently been installed. The steam-raising plant which provides the steam required not only for the turbo-generators but also that needed in connection with the production of about 1500 t. of patent fuel per day, comprises three Loeffler-type boilers producing steam at a pressure of 1764 lb. per sq. in. and at a superheated temperature of 887 deg. F. The boilers of which each generates about 40 t. of steam per hr. are fired by lignite. The generating plant comprises two 8500-12000-kw. three-stage turbines and generators. It is added that the boilers have already been run for 12,000 hr. without any trouble being experienced.

IN SWISS hydraulic plants at altitudes above 3000 ft. it has been found advisable to cover both sides of concrete dams with stone to prevent damage of surfaces by frost.

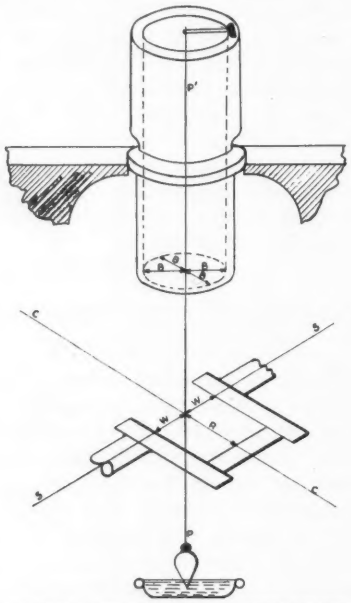
Plant Operation Problems

Lining Up Diesel Cylinders

WE HAVE a trunk type Diesel engine with the lower part of the cylinder and upper part of the base not doweled or marked. We wish you would advise us the proper method of lining up the cylinder. R. M. H.

A. From the mention of no dowels, probably the same cylinder is going to be used again either by reboring and using an oversize piston or reboring and bushing the cylinder and using the same piston. With the cylinder still in place the flanges of the cylinder and the base should be marked at two places about 90 deg. apart so that the cylinder can be exactly replaced in its former position after reboring. This should have been done when the engine was erected and certainly by the repair man before the parts were removed.

If the repair man was not sufficiently trained to mark parts before taking them apart, he can hardly be expected to use accurate tools, in which case I think he should first put the cylinder on; then adjust the bearings to close running clearances; insert the piston and move the cylinder until the parts assembled without forcing on top dead center and bottom dead center. After this the piston can be checked with feelers between the skirt and cylinder wall to see if it is free and centered. I have used this method after relining cylinders of cross head engines and find it sufficiently



METHOD OF LINING UP CYLINDER

accurate in the majority of cases. If the parts do not re-assemble by their own weight, I have always found that either the liner was pushed out of line or some bearings were more worn on one side than on the other.

A more accurate method is explained below:

Referring to the diagram, the crankshaft is set with the crank 90 deg. from dead center, the cylinder placed on the base and a plumb line dropped through the bore. The line is centered at the top of the bore and the plumb bob is set so that its end rests in a pan of heavy oil to dampen out vibrations and to bring it quickly to rest. With an inside micrometer, measure the distances B at the bottom of the bore. These should be equal. If they are not, with the bed plate or engine base level, the cylinder is tipped, and the bore is not perpendicular to the flange so the latter must be filed or scraped to bring the cylinder vertical. That done, the cylinder is adjusted until the distance W between the crank webs are equal and the distance R equal to half the stroke minus half the diameter of the crankpin. If the engine is for some reason not level or not vertical then center lines such as SS′, CC′ and PP′ can be used with a square and a level.

(Answered by J. J. McDougall, Globe, Ariz.)

Power Generation

WE ARE THINKING of installing a unit for generating current for power and light. Our motors are grouped in two departments, the first with a total connected load of 380 hp. with two furnaces totaling 17 kw., the second department with a connected load of 220 hp. and motors. The maximum lighting load as given by the company's meter is about 50 kw.

At the present time our boiler equipment consists of two 100 lb. ga. h.r.t. boilers, one 150 and one 125 hp., each equipped to burn coal, sawdust or shavings. We need to operate only one boiler at a time. During the summer months we have an excess of wood to burn so that our boilers pop off much of the time.

Our plan is to generate current with steam from the boilers using the exhaust for heating and process at from 5 to 10 lb. back pressure. Could we carry this load with our present equipment? And how could we determine whether or not our steam and electric loads agree during the hours of the day?

A. Your 150 lb. boiler operating at normal rating would generate about 4500 lb. of steam per hr. This amount of 100 lb. saturated steam with back pressure of 10 lb. per sq. in. and 75 per cent engine efficiency would develop about 150 hp. or, allowing for generator efficiency, perhaps 100 kw. This would be more than sufficient to take care of your lighting load and perhaps carry one or two of the motors.

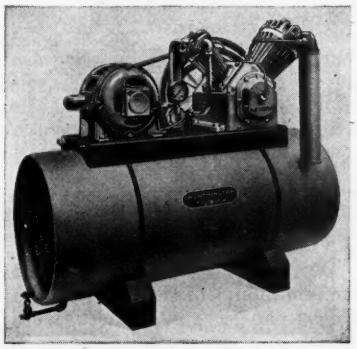
It is difficult to tell just how the steam and electric loads would coincide. By reading the electric meter every half hour or every 15 minutes, if you desire closer readings, it would be possible to determine a representative curve of electric power consumption. A steam load curve might be approximated in several ways, either by the amount of fuel which you burn if you have a scale handy or by the amount of water delivered by the feed pump. If you will connect an old counter on the boiler feed pump and read this counter every 15 minutes or half hour, the number of strokes can be determined. From the number of strokes and size of pump you can approximate the water delivered to the boiler and although this does not give you an absolute value it will give you a curve which will show variations of your steam load throughout the day. You can compare this with the electric load and find out how they agree.

New Equipment

Compressor Unit

COMPLETE LINE of V-type, two-stage, air-cooled air compressor units especially designed for automotive service has been announced by Worthington Pump and Machinery Corp., Harrison, N. J. The new compressors, equipped with feather valves, are designated as Type VA-2 and are offered in a range of sizes to furnish from 3.9 to 34 c.f.m. at pressures up to 200 lb. per sq. in.

Features of advanced engineering are incorporated, including counter-balanced crankshaft, full-floating wrist pins, honed cylinders, silent suction muffler and Timken roller bearings. Motor and compressor, connected through a Worthington Multi-V-Drive, are mounted on a channel base resting upon a horizontal A.S.M.E. air receiver, the



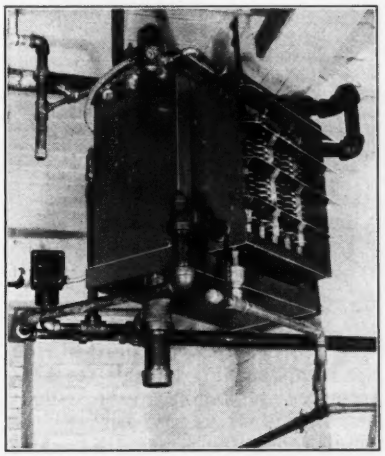
base being joined by straps to sturdy iron floor saddles.

Enclosed in the crankcase is a centrifugally-operated automatic mechanical unloader, providing positive operation of bypass needle valve for unloading the compressor in starting. A spring-loaded air safety valve assures dependability of action and gives adequate protection against excess pressure. An air-operated electric pressure switch provides fully automatic start and stop control.

Speed Heater Humidifiers

FOR LOCAL control of humidity in plants and factories, the B. F. Sturtevant Co., Hyde Park, Boston, Mass., has developed this equipment consisting of a fan, unit heater and humidifier, arranged to control local conditions as to temperature and humidity of the air over a desired area.

Heater and fan are of the usual type for unit heating. The humidifying equipment on the discharge from the heater has vertical rows of cups, the water flowing down from petcocks at the top that are set for the required flow of water, each



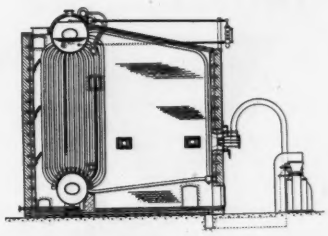
cock feeding two rows of cups. At the bottom, a drip pan carries any overflow to a waste line. Flow of water is controlled by an electric motorized valve, operated by a hygrostat and a reducing valve, set to regulate pressure to the water element. Thermostatic control of the fan and the steam supply prevent fan and humidifier operation until steam has completely filled the heater unit and regulate the steam and air flow.

Three sizes are made: 75 with 312 sq. ft. of radiation to evaporate 4½ gal. of water per hr.; 100 with 409 sq. ft. for 7 gal. per hr.; 150 with 596 sq. ft. for 9½ gal. per hr.

Steam Generating Unit

COMBUSTION ENGINEERING CORP., New York, N. Y., announces the C-E Steam Generator Unit, a standard design built in a range of sizes for capacities of 8000 to 40,000 lb. of steam per hour. It comprises an assembly of standard equipment, and involves no radical departures from established practice. Its low headroom and small floor space requirements make it particularly suitable for the limited space conditions found in many plants. The fact that it may be fired by pulverized fuel, oil or gas provides the advantages of wide choice of fuels, ability to pick up or drop load quickly, high average efficiency and no banking losses.

The unit comprises a two-drum vertical boiler and a furnace of solid brick walls, the top and front of which are water-cooled by tubes connecting into the upper boiler drum



and terminating in a header in the lower front wall. A water screen across the furnace bottom connects this header with the lower boiler drum. Pulverized fuel is fired horizontally by a natural draft burner to which fuel is supplied by a Raymond Impact Pulverizer Mill, located either in front or to one side of the unit. The boiler can be arranged for either two or three gas passes and may be equipped with a superheater.

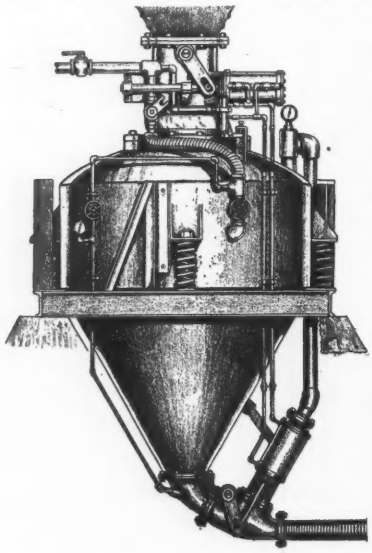
Pneumatic Transport System

PNEUMATIC system for conveying of cement, pulverized coal, and other fine materials has been announced by the Kennedy-Van Saun Mfg. & Eng. Corp., New York, N. Y. The transporting apparatus may be connected to the discharge opening of the bin containing the material to be conveyed or receive its feed from a conveyor, or it may take the discharge direct from a pulverizer. It consists of a weighing tank which is automatically filled and emptied by air pressure.

Air-operated pistons have adjusting means for timing their movement so that the filling and discharging cycle may be regulated to suit individual plant conditions, capacities, piping layouts, and the different materials to be handled. After being set for one operating condition, no further adjustment of the timing valves is required. The transport line itself consists of standard

pipe of the proper size required for a particular installation.

The system also automatically weighs the material discharged, since a given weight in the container

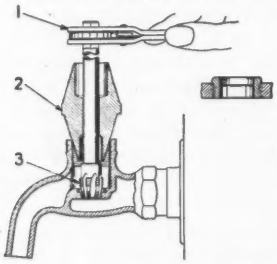


is necessary to operate the pilot valve. The weight required to discharge the container is known. The number of discharges from the container multiplied by this weight is a definite and accurate record of the weight of the material transported. A tachometer for counting the dumps is all that is required.

Saver Renewable Seat Tool

CONVERTING VALVES with integral seats into the renewable seat type is the function of the tools recently developed by the Saver Renewable Seat Tool Co. of Chicago. In sizes up to ¾ in., the form of the tool is a combination reamer and thread tap, in larger sizes the reamer and tap are separate tools.

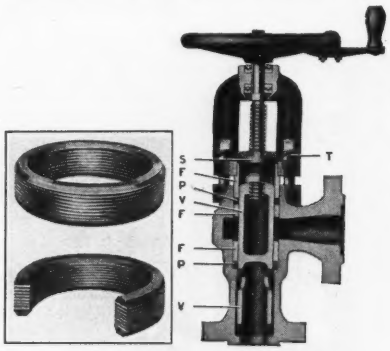
To use the tool, remove the valve



bonnet and stem, select the size reamer or tap to fit into the seat opening, insert tool in centering cone and put tap in valve seat opening, tighten the cone and with ratchet wrench ream or tap the hole driving the tap right through. The valve is then ready for the insertion of a new seat.

Blowoff Valve Packing for High Pressure Service

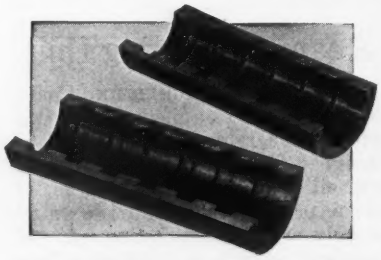
LAMINATED PACKING for use in Yarway seatless blowoff valves for the higher steam pressures has recently been developed by Yarnall-Waring Co. of Philadelphia. This packing consists of several rings of stainless steel with long fiber asbestos packing between them. The assembled rings are compressed and



heat treated so that the finished ring is a complete unit suitable for high pressures and temperatures. Slight clearance is maintained between the metal laminations and the valve plunger. In blow-down tests, this packing has withstood steam pressures as high as 2100 lb. per sq. in. without evidence of leaking.

Gatke Non-Metallic Bearings

SUCCESSFUL SERVICE in steel rolling mills has resulted in the development by the Gatke Corp., Chicago, of a complete line of molded non-metallic bearings for all general machinery uses. These bearings are composed of a special textile base impregnated with synthetic resins. They are molded of three basically different materials, thus

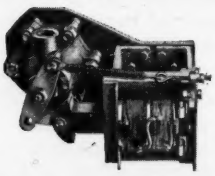


making a type available for various specific services such as in water or where water is used as lubricant, where oil lubricant is used, and where the bearing must be self-lubricating.

Nicholson Solenoid Operated Valves

DESIGNED FOR solenoid operation and used where it is desired to operate single or double acting cylinders by remote control through a push button station or automatic time cycle device, these new valves developed by W. H. Nicholson & Co., Wilkes-Barre, Pa., are manufactured in two, three and four-way types. In one model current through the solonoid holds the valve open against the tension of a spring which closes the valve when the current is off. Another model is designed with a ratchet and rotary disc so that energizing the solonoid moves the disc from one position to another.

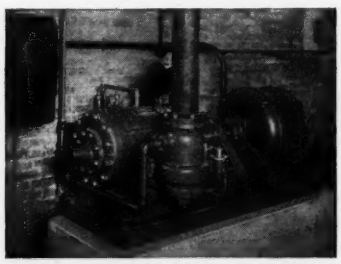
In this unit the company uses the flat disc, regrinding type of valve that has been a standard for



years. It has a generous size stuffing box in addition to a beveled shoulder on the stem seating against the body, giving two seals against leakage.

Single-Stage Rotary Air Compressor

ROTARY AIR COMPRESSORS and vacuum pumps of the multi-cellular, sliding-vane type, in both water-cooled and air-cooled designs, are



now made available by Allis-Chalmers Mfg. Co., Milwaukee, Wis. The complete line covers a range of volumes from 50 to 2000 c.f.m. at pressures up to 150 lb., and vacuums up to 29.85 in. mercury. The air-cooled units are suitable for pressures up to 10 lb. g, and vacuums up to 18 in. hg, and the water-cooled units for higher pressures and vacuums. The smooth operation, small dimensions, continuous delivery and absence of maintenance requirements are a few of the advantages presented.

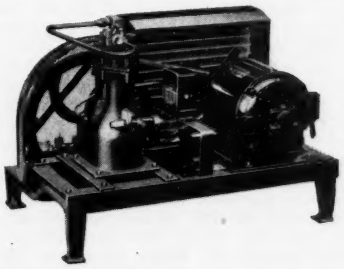
New B. & W. Firebrick

BABCOCK & WILCOX Co. announces the addition of a new firebrick, B & W 80 Junior, to its line of refractory products. This refractory was developed to meet economically the conditions existing between moderate service and severe conditions. It has a melting point of 3175 deg. F. and its pyrometric cone equivalent is 33. Its shrinkage is only 0.85 per cent after reheating at 2900 deg. F. for 5 hr.

This firebrick has, under test, withstood 18 cycles of alternate heating to 2900 deg. F. and cooling with an air blast with a loss of 20 per cent by spalling. Under the A.S.T.M. test C-16 to determine its deformation under load, B & W Junior firebrick showed no deformation at 2660 deg. F. and 10 per cent at 2780 deg. F.

Small Refrigerating Units

LOW PRESSURE UNITS, charged with methyl chloride, have been added to its line of industrial refrigerat-



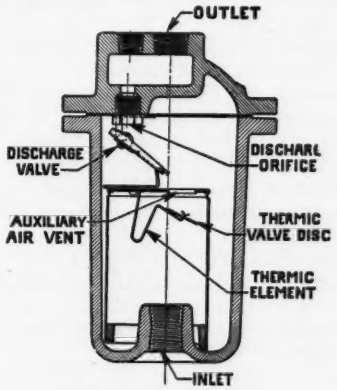
ing machinery by the Frick Co. of Waynesboro, Pa.

These small machines, being driven with motors of ¼ to 3 hp., are suitable for commercial installations in many trades and industries. The Units, which are finished in maroon enamel to conform with other Frick machines, are readily adapted to use with freon when required.

Heat Controlled Air Bypass

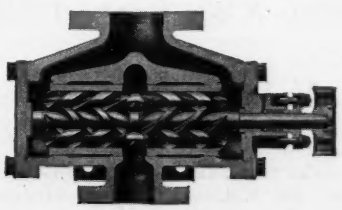
TO PROMOTE QUICK HEATING, an automatic air bypass integral with the Armstrong inverted bucket steam trap has been developed by the Armstrong Machine Works of Three Rivers, Michigan.

This special trap bucket designed especially for quickly removing air from unit heaters, jacketed kettles, hot water heaters or pipe coil radiation, has a large auxiliary air vent which is closed by a flat disc of stainless steel on the end of a strip of rustless thermostatic bimetal which in turn is double riveted to the bucket cap. As long as the trap is cold, the disc is held away from the vent and air escapes so rapidly that the bucket cannot float and close the discharge valve. Air blows through until steam fills the radiation space and reaches the trap causing the thermic strip to seat the disc which prevents steam from escaping through the auxiliary vent. Thereafter, the trap functions in the normal manner and any air that may be mixed with the steam will escape through the standard fixed vent.



Rotary Pumps

FOR EFFICIENT COMBUSTION, oil burners should be supplied with oil at constant pressure in order that the oil may be atomized uniformly at all times. This is accomplished by a new pump of the De Laval Steam Turbine Co., Trenton, N. J., known as the De Laval-IMO pumps which have an action like that of a piston acting continuously in one direction, giving steady pressure for the burners. In addition, they are adapted for steam turbine drive, which, with a pressure control device, gives a smoothly variable speed.



The pumps are made in single end, single suction types, with all thrust in hydraulic balance, or balanced opposed rotor types, as shown by the sectional drawing. In the latter, oil is received at the ends of the rotors and delivered from the middle. Inasmuch as there are no timing gears, only one stuffing box is required and that is under suction pressure only, provision being made for sealing where suction lift is encountered. Since the power rotor and the two idler rotors are double acting, there is no end thrust, except that due to the suction pressure against the unbalanced area of the shaft driving the power rotor.

World Power Conference

AN ELABORATE PROGRAM with 175 papers and numerous inspection trips will feature the two weeks Sectional Meeting of the World Power Conference which opens in Stockholm June 26 concurrently with the First International Congress on Large Dams, an organization operating under the World Power Conference.

Papers from the United States include: Electric Heating in the United States, by R. M. Cherry and J. C. Woodson; A History of Recent Traction Power Developments on the New Haven Railroad, by Sidney Withington; Coördinated Production of Industrial Steam and Utility Power, by A. R. Smith; Development and Application of Energy in the Mining and Metallurgical Treatment of Copper Ore, by Wilbur Jurden; Energy Requirements of the Aluminum Industry, by T. J. Bostwick; Hydraulic-Fill Dams, by Glennon Gilboy; and Internal Temperature and Deformation of Masonry Dams, by Messrs. Houck and Steele.

The American delegation will be accompanied by O. C. Merrill, chairman of the American Committee.

News from Washington

AFTER EXTENDED consideration, the Federal Power Commission has just handed down a decision of considerable importance, as it involves the right of the Commission to approve or disapprove the construction of a power plant under its license, as far as the equipment and other parts are concerned, especially as regards economical construction and efficient operation. In others words, if the Federal Power Commission in considering the plant to be equipped under a license, determines that the plant is not economical or efficient, it takes the position that it can cause the plant to be changed in accordance with design and operation that will make the cost of production and charges to the public reasonable.

This ruling was made in that just issued on the license of the Columbia Railway & Navigation Co., having a project on the Santee and Cooper rivers in South Carolina. The company was compelled to establish an accounting system in accordance with those required by the Commission. The company then extended its project plans and in passing on these plans the question came up as to economical construction and efficient operation.

A.S.H.V.E. To Meet in Detroit

SESSIONS OF THE PROGRAM for the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, will be held in Hotel Statler, Detroit, Mich., June 22 to 24. An active committee has been organized under the leadership of L. L. McConachie. During the technical sessions, reports on a variety of subjects will be given and among the group selected by the Program Committee are: Test Results on the Conductivity of Different Grades of Lumber; Heat Dissipation from Insulated Hot Water Pipes; Measurement of Air Flow through Grilles; Heat Output from Concealed Radiators; Air Stratification in Assembled Halls, as well as data from the A.S.H.V.E. Research Laboratory.

Power Show at Chicago to be at the Stevens Hotel

THE 6TH POWER SHOW at Chicago previously scheduled for the Coliseum will be transferred to the Exhibition Hall of the Stevens Hotel, the center of Engineering Week activities of A Century of Progress.

This change in location will permit the engineers attending professional meetings in Chicago conveniently to visit the show between sessions, and brings together the week's big Engineers' Day banquet and the exhibit in the same building.

Approval of participating in Engineering Week of the World's Fair has been given already by 19 engineering associations. Others will also participate. The organizations coöperating are as follows:

American Association for the Advancement of Science
American Association of Engineers
American Ceramics Society
American Foundrymen's Association
American Institute of Electrical Engineers
American Institute of Mining and Metallurgical Engineers
American Society of Civil Engineers
American Society of Mechanical Engineers
American Society of Municipal Engineers.
American Society for Testing Materials
American Society of Agricultural Engineers
National Council of State Boards of Engineering Examiners
Society for the Promotion of Engineering Education
Society of Industrial Engineers
Institute of Radio Engineers
Western Society of Engineers
American Society of Refrigerating Engineers
American Welding Society
National Industrial Advertisers Association
National District Heating Association.

A. S. T. M. Convention

AT THE THIRTY-SIXTH Annual Meeting of the American Society of Testing Materials to be held June 26-30 at the Stevens Hotel in Chicago, the Eighth Edgar Marburg Lecture will be presented by Dr. H. E. Gough, Superintendent of the Engineering Department of the National Physical Laboratory of England. The subject of the lecture is the crystalline structure in relation to the failure of metals especially by fatigue. Fourteen sessions are planned but in arranging the program of the meeting consideration was given to the unusual number of activities running concurrently in Chicago. Joint meetings with other societies include the American Foundry Men's Association and a joint session on economies at the Palmer House with the Econometric Society, A. S. M. E. and A. I. E. E.

N. D. H. A. Meets in Chicago

AT THE PALMER HOUSE in Chicago, the National District Heating Association will hold its Twenty-fourth Annual Convention, June 27-30. In addition to the usual committee reports a number of unusually interesting papers will be presented dealing primarily with cost and construction of distributing methods and station operation.

Among the papers of more immediate interest to the power engineer are: Line Loses and Delivery of Superheated Steam by P. F. Helm; Heating Effect of Underground Steam Lines by W. A. Herr; Distribution System in Washington, D. C., by A. J. Slade; Bituminous Coal Rates by Chas. O'Neill; Gas Washing for Sulphur Dioxide by H. F. Johnstone; Feedwater Treatment by S. T. Powell; Competitive Fuels by George Orrok, Jr. and By-product Generating Cycles by R. G. Felger.

News From the Field

WORTHINGTON PUMP & MACHINERY CORP. on May 1 opened its new office building, situated adjacent to the corporation's plant at Harrison, N. J. The general and executive offices, formerly situated at 2 Park Avenue, New York, have been moved to the new location but the local sales office will be continued at 2 Park Avenue.

THE VULCAN SOOT BLOWER CORP., a Pennsylvania corporation, of Du Bois, Pa., manufacturers of Vulcan Soot Blowers, has been organized as successors to The Vulcan Soot Cleaner Co. Officers of the new corporation are: J. R. Osborn, president, Fred J. Brown, vice-president, J. E. Du Bois, M. H. Hartzfeld and J. Q. Groves, directors, W. N. McCreight, secretary and treasurer, D. E. Hibner, Jr., chief engineer and Fred C. Arey, consulting engineer, all of Du Bois. The corporation succeeds to a pioneer business established in 1907. Sales representatives are located in New York City, Philadelphia, Pittsburgh, Erie, Cleveland, Chicago, Washington, St. Paul, Winnipeg, New Orleans, Buffalo, Cincinnati, Dallas, Indianapolis, St. Louis, Milwaukee, Seattle and Toronto.

L. H. STATES, formerly connected with the Philadelphia Office of the Allis-Chalmers Mfg. Co., of Milwaukee, Wis., has transferred to Syracuse, N. Y. He will handle the principal products of the company for the central part of that state.

ANNOUNCEMENT is made by Will J. Sando, consulting engineer of Milwaukee, Wis., that O. H. Henschel, electrical engineer, and Henry J. Geerlings, mechanical engineer, has become associated with him in carrying out engineering projects dealing with power houses, hydro-electric plants, sewage disposal plants, gasoline cracking plants, public utilities and investigations, engineering reports and appraisals and industrial engineering.

THE PEABODY ENGINEERING CORP. has moved its main offices from 40 East 41st St. to 580 Fifth Ave., New York City and has also recently taken over a factory in Stamford, Conn., where all Peabody equipment will be manufactured.

THE BUFFALO DISTRICT Sales office of Republic Steel Corp. has been moved to 475 Abbott Road, Buffalo, N. Y. Thos. B. Davies, District Sales Manager, and his present staff will continue in charge at the new location.

For the Engineer's Library

OUR MINERAL CIVILIZATION. By Thos. T. Read. Published by Williams and Wilkins Co., Baltimore, Md. 5 in. by 7 in., 165 p., cloth bound. Price, $1.00. One of the Williams and Wilkins Co. Century of Progress Series.

Mr. Read has included under the term "minerals" all substances which in the popular sense, as in the game of "Twenty Questions," are neither animal nor vegetable. The book contains chapters on coal; iron; copper, lead and zinc; chemicals; and the rarer metals. He has shown in an exceedingly interesting manner how it would be utterly impossible even to imagine modern civilization if we were deprived of the use of minerals. This book is not a statistical compendium but an entertaining story of man's progress in utilizing minerals to augment his natural capacities.

THE NEW NECESSITY, by C. F. Kettering and Allen Orth. Published by the Williams and Wilkins Co., Baltimore, Md. 5 in. by 7 in., 124 p., cloth bound. Price, $1.00. One of a series prepared by the Williams and Wilkins Co. and its associates in coöperation with A Century of Progress Exposition.

This little book has not attempted to serve as a history of the automobile industry nor is it an attempt to glorify the automobile, but rather to present certain aspects of the industry which may have escaped the attention of the layman. The book begins with a brief description of the evolution of the machine from the motor driven tricycle of Benz, first shown in America at the Chicago World's Fair of 1893, to the much more efficient and beautiful machine of today. It then carries you through the highly interesting story of the growth of the industry, its problems and the way it has affected practically every industry and the life of every person in America.

PRODUCTION OF MANUFACTURED ICE AT LOW BRINE TEMPERATURES. By Dana Burks, Jr. Published as Bulletin No. 254 by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Size 6 by 9 in., 63 pages, paper. Price 70c.

Report of the results obtained in the study of ice production from a standpoint of operating efficiency and development of methods rendering increased efficiency possible. Operation of the experimental ice plant indicated that with brine temperatures reduced to 6 deg. F., freezing time could be reduced 50 per cent over commercial 16 deg. brine. Analysis of overall production cost, indicated a possible reduction of 30 per cent.

Production of marketable ice at low brine temperatures presented special difficulties, however, the chief of which were an increased tendency for the ice formed to be opaque and the tendency of the blocks to shatter due to strains developed in the process of removal from the cold brine. The first difficulty was successfully overcome by effective air agitation (described in former bulletins No. 219 and No. 253.) The second difficulty was remedied by two methods, one of which involves pre-treatment of the water and the other controlled annealing of the cans containing the ice following removal from the brine.

A limited number of copies are available for free distribution.

"THE WELDING OF ENDURO STAINLESS ALLOYS," is the title of a booklet being released for distribution by Republic Steel Corporation, Central Alloy Division, Massillon, Ohio. The booklet contains information on various welding methods as applied to different types of Enduro Stainless Alloys, including Electric Arc Welding, Gas Welding, Spot and Projection Welding, Seam Welding and Flash Welding.

AMERICAN STANDARDS YEAR BOOK published by the American Standards Association, 29 W. 39th St., New York City, tells what has been accomplished by the Association since 1918 and shows to what extent industrial self-regulation has been successful. A smaller booklet, entitled "Does Industry Need a National Standardization Agency" gives a few striking examples of how the A.S.A. performs an essential service for industry under a democratic procedure that insures to every interested group the right to have its viewpoint considered when setting up industrial standards.

FOUR-CYCLE DIESEL ENGINES of the fully enclosed solid injection design known as Type FS-16 is described in Bulletin No. 51 issued by the Nordberg Mfg. Co., Milwaukee, Wis. The engine is built from 2 to 8 cylinders ranging from 250 to 1000 hp.

UTILIZATION OF HEAVY OILS in enrichment of water gas by means of the new Semet-Solvay ignition arch process is described and illustrated by a model in a recent bulletin, No. 46, issued by the Semet-Solvay Engineering Corp., 40 Rector St., New York, N. Y. The model shows a water gas carburetor, accurate as to scale and arrangement, illustrating the refractory arches, built at right angles to each other, which feature this new process.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., is distributing a new bulletin designated as No. 149 entitled "Equipment for the Modern Brewery and Malt House" which deals in a general way with power generating equipment, motors, pumps and brewing machinery manufactured by the company.

DE LAVAL STEAM TURBINE CO. of Trenton, N. J., has reprinted, for distribution, a paper describing the new water filtration plant and pumping station at Highland Park, Ill., by Paul Hansen. An exhaustive comparison is made of the merits of seven different kinds of pumping equipment, including electric motor driven pumps, oil electric drive, oil engine drive, steam turbines in combination with oil engines, steam turbines in combination with motor drive, and two types of steam turbine driven pumps. The lowest cost of pumping is shown by the combination of steam turbine pumps and electric motor driven pumps, although for the conditions of this particular plant, involving capacities ranging from 2 to 6 million gallons per day against a 220-ft. head, electric driven pumps alone are a close second, and as the station is located in a high class suburban district where coal handling equipment and chimneys were not desirable, they were selected.

GRINDING, POLISHING AND BUFFING of Monel Metal and Pure Nickel is the title of a technical paper just published by the International Nickel Co. of New York.

BULLETIN FILE NO. 32 on Brewery Equipment has just been released by the York Ice Machinery Corp. of York, Pa. The subject matter deals with ammonia compressors, condensing equipment, tanks, exchangers, pasteurizers and air conditioners.

UNDER THE TITLE of Telemetering and Totalizing Station Loads, designated as Bulletin No. 874, Leeds & Northrup Co., Philadelphia, Pa., issues its fourth pamphlet in a series on power plant instruments. It discusses means for providing the load dispatcher of an electric power system with continuous information on load conditions throughout the system, to facilitate load distribution in ordinary conditions and to aid in control of emergencies.

"THE NEW STORY of Ancient Wrought Iron" is the title of a booklet recently issued by A. M. Byers Co., Pittsburgh, Pa., which contains an interesting description of the process of wrought iron making as carried out by the Byers Co., the illustrations used being actual scenes taken by motion picture camera in the plant of the company.

INDICATING THERMOELECTRIC TYPE pyrometers are made the subject of a pamphlet just issued by the Mishawaka Industrial Instrument Manufacturing Laboratory of Mishawaka, Ind. The standard instrument ranges are from 32-800 to 32-3000 deg. F., one model being especially suited for indicating Diesel engine cylinder temperatures.

SUPERIOR ENGINE CO., Springfield, O., has just issued its Bulletin No. 128 dealing with the features of Superior Diesel stationary engines, the descriptions being aided by halftone illustrations of cross sections and characteristic curves of the engines.

CRANE CO., Chicago, Ill., is distributing two interesting booklets. The first, "Born of Retrenchment," deals with obsolescence and waste resulting from inadequate repair, maintenance and replacement. The second, "After 3 Years of Starvation Maintenance," explains practical methods by which to determine whether or not the piping equipment of a plant is as efficient and up-to-date as it should be.

WORTHINGTON PUMP and Machinery Corp. and Gamon Meter Co. announce consolidation of their operations in the manufacture and sale of meters, through the newly organized Worthington-Gamon Meter Co. Sales headquarters for the company have been established at Harrison, N. J. All manufacturing operations, however, will be concentrated in the Gamon plant nearby, in Newark, N. J. Officials are as follows: E. T. Fishwick, President; G. H. Gleeson, Vice President in Charge of Sales; J. A. Bonnet, Secretary; R. R. Anderson, Works Manager.

THE ENGINEER CO. has just published a new bulletin on oil burning which shows some high powered equipment, having capacities up to as high as 3000 b.hp. per unit. There are other notes on these large power plants which should be of interest.

Power Plant Construction News

Ariz., Tucson—Arizona Ice & Cold Storage Co., Tucson, is planning construction of one-story ice-manufacturing and cold storage plant at Elroy, near Tucson, with capacity of about 20 tons per day. Cost $60,000 with equipment.

Calif., Alhambra—Board of Public Works, T. B. Downer, city water superintendent, plans installation of two electric-operated deep-well turbine pumping units, each about 150 hp., two booster pumps and other mechanical equipment, including 24-in. pipe lines, in connection with water supply system in Rio Hondo district. Entire project will cost about $340,000.

Calif., Los Angeles—Bureau of Power and Light, 207 South Broadway, has plans and specifications under way for steel tower transmission line from city to Hoover Dam, Boulder City, Nev., including 2256 steel towers for 271-mile system. About 111 miles will be double towers, and 60 miles, single towers. Program will include insulators, oil-circuit breakers, transformers and other equipment. Bids will soon be asked for different features of work. Fund of $22,800,000 will soon be available.

D. C., Washington—Potomac Electric Power Co. has filed plans for construction of new coal-handling plant at power station on V Street, Southwest, estimated to cost about $30,000, with equipment. Stone & Webster Engineering Co., 80 Federal Street, Boston, Mass., is consulting engineer.

Ind., Mishawaka—Ohio Power Co., Newark, Ohio, has authorized construction of a new transmission line from generating plant at Philo, near Zanesville, Ohio, to Mishawaka and vicinity. Cost estimated over $500,000 including power substation and switching facilities.

Iowa, Rockford—Common Council is completing plans for a municipal electric light and power plant and distributing system, and plans early purchase of prime movers, transformers, switchboard and other equipment. An appropriation of $105,000 has been arranged for project. H. L. Cory Co., Redick Tower Building, Omaha, Neb., is consulting engineer.

Kan., Burlington—Common Council has called special election to approve a bond issue of $118,000, of which $85,000 will be used for construction of a municipal electric light and power plant, and $33,000 for electric distributing system. E. T. Archer Co., New England Building, Kansas City, Mo., are consulting engineers.

Ky., Harlan—Elkhorn Piney Coal Co. plans installation of electric power equipment, elevating and other mechanical equipment in connection with rebuilding of head house at operating plant, recently destroyed by fire with loss of about $30,000.

Md., Baltimore—Department of Public Works, Municipal Office Building, will have plans drawn for new pumping plant for municipal water system at Ashburton, to include installation of two main pumping units with capacities of 18,000,000 and 12,000,000 gals. per day, respectively. Cost over $350,000. Proposed to begin work in the fall.

Mich., Detroit—Great Lakes Steel Corporation, Ecorse, Detroit, will install electric power equipment at new slag plant at local mill, estimated to cost about $100,000. Company is a subsidiary of National Steel Co., same address.

Mich., Grand Rapids—Great Lakes Brewing Co., care of Neal W. Taplin, 112 Barclay Avenue, N. E., recently organized by Mr. Taplin and associates, plans installation of electric power equipment, mechanical-cooling, bottling, conveying and other equipment in new brewing plant at Bridge Street and Indiana Avenue. A boiler house will be built. Entire project will cost about $250,000.

Mich., Sebewaing—Village Council is considering new addition to municipal electric light and power plant, with installation of additional equipment. Cost close to $50,000, of which about $35,000 will be expended for equipment.

N. Y., Long Island City—Edward & John Burke, Ltd., 47-24 Twenty-seventh Street, Long Island City, brewers, plan installation of electric power equipment, bottling machinery, conveyors and other mechanical equipment in new six-story bottling and distributing plant at Skillman Avenue and Twenty-seventh Street. Cost over $100,000.

N. Y., Syracuse—George Zett Brewing Co., Syracuse, recently acquired by new interests, headed by Louis A. Wehle, president of Wehle Baking Co., 174 Clarissa Street, Rochester, N. Y., and associates, plans installation of electric power equipment, bottling machinery, conveyors, etc., in connection with an expansion and improvement program to cost about $80,000.

Ohio, Chillicothe—August Wagner & Sons, Chillicothe, plans complete electrification of brewing plant, installation of refrigerating machinery, pumping and water supply equipment, and other machinery in connection with an expansion and improvement program. Cost over $85,000. Bassett & Tresselt, Columbus, Ohio, are architects; Carl J. Kiefer, Schmidt Building, Cincinnati, Ohio, is consulting engineer.

Ohio, Cincinnati—City Council, C. A. Dykstra, city manager, is arranging an ordinance to provide for installation of a municipal electric distributing system in certain parts of city. Estimated cost about $750,000. Fosdick & Hilmer, Union Trust Building, are consulting engineers.

Ohio, Cleveland—Cleveland Electric Illuminating Co., Illuminating Building, has approved plans for new power substation at Cuyahoga Heights, reported to cost over $85,000 with equipment. Company engineering department is in charge.

Ohio, Eaton—City Council is considering installation of a municipal electric distributing system. Surveys and estimates of cost will be made by Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., consulting engineer.

Ohio, Middletown—Premier Beverage Co., Middletown, operating Sebald Brewery, plans installation of electric power equipment, bottling machinery, mechanical-cooling and other equipment in connection with expansion and modernization program. Entire project will cost over $100,000.

Ohio, Painesville—Standard Chromate Co., manufacturer of chrome products, plans installation of electric power equipment in new plant addition. Entire project estimated to cost over $50,000.

Ore., Portland—Oregon Breweries and Hopyards Affiliated, James E. Edmiston, American Bank Building, president, plans installation of electric power equipment, refrigerating and other mechanical equipment in proposed new brewing plant. Entire project will cost over $300,000. A one-story boiler house will be built.

Pa., Altoona—American Brewery, V. A. Oswald, head, plans installation of electric power equipment, conveying and loading machinery, and other mechanical equipment for an expansion and modernization program. Cost over $65,000.

S. C., Anderson—Appleton Co., Anderson, has plans under way for extensions and improvements in power plant, to include installation of steam turbine and accessories, boilers and other equipment. Cost about $150,000, with equipment. J. E. Sirrine & Co., Charlotte, N. C., are consulting engineers. D. D. Little is president.

Tenn., Memphis—Tennessee Brewing Co., Memphis, care of C. M. Bishop, Floyd Piano Co., 162 Madison Avenue, recently organized by Mr. Bishop and associates, plans installation of electric power equipment, mechanical-cooling, tanks and other equipment in proposed new brewing plant. A boiler house will be built. Entire project is reported to cost over $150,000.

Texas, Houston—Southern Pacific Railway Co., Houston, plans installation of power plant for central heating and other operating service in new local multi-story passenger and freight terminal. A fund of $1,200,000 has been arranged for project. Company engineering department will be in charge.

Utah, Koosharem—Peoples Light & Power Co., Loa, Utah, is considering construction of new steam-operated electric power plant in Grass Valley district, vicinity of Koosharem. Cost reported over $80,000, with transmission line.

W. Va., Kanawha City—Owens-Illinois Glass Co., 965 Wall Street, Toledo, Ohio, manufacturer of bottles, etc., plans installation of electric power equipment in proposed addition to glass plant at Kanawha City, estimated to cost over $125,000. Company engineering department is in charge.

W. Va., Moundsville—Ben Franklin Coal Co., has approved plans for construction of new steam power plant at local coal properties, estimated to cost over $80,000, with equipment. Work scheduled to begin at early date.

Wis., Eau Claire—City Council plans installation of pumping machinery and auxiliary equipment, pipe lines, etc., for extensions and improvements in municipal waterworks. Cost about $125,000. Pearse, Greeley & Hansen, 6 North Michigan Avenue, Chicago, Ill., are consulting engineers.

Wis., Green Bay—Board of Public Works has authorized complete electrification of municipal waterworks and will install new equipment. J. S. Hartt, 122 West Washington Avenue, Madison, Wis., is consulting engineer.